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The Kent Incorporated Society for Promoting Experiments in Horticulture

ANNUAL REPORT

(TWENTY-EIGHTH YEAR)

1940

IMPERIAL MYCOLOGICAL INSTITUTE
22 OCT 1941

EAST MALLING RESEARCH STATION

Near MAIDSTONE KENT

1st January, 1940 to 31st December, 1940

Free to Associate Members
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Great Britain only

Published August, 1941

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FOR PROMOTING EXPERIMENTS IN
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G. WELLER. (*Workshop and Recorder. Appointed April* 1941.)
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* Recognized Teacher of the University of London.

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Meteorological Records : H. C. CHAPELOW.

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VISITORS.

The headquarters of the Technical and Advisory Section have been moved to Bradbourne, Larkfield, and visitors are asked to call there before going to the Station and not to proceed direct to the Laboratories at East Malling.

All *correspondence* should still be addressed to East Malling Research Station, near Maidstone, Kent.

Visits may be paid on any weekday, *by appointment* if possible (Saturday afternoon under exceptional circumstances only).

Passenger Station : East Malling Halt (Southern Railway). *Goods Station :* Aylesford (Southern Railway).

Bus Services : FROM MAIDSTONE by the Maidstone and District Motor Services Limited, every 20 minutes from Maidstone to Larkfield. FROM LONDON the coaches call at East Malling and Larkfield on certain inward and outward journeys.

Visitors coming by road should take the turning to East Malling Village, opposite the Bull Hotel, Larkfield, on the main London-Maidstone Road. The entrance gate to Bradbourne is on the left approximately 100 yards down the road.

Telephone : Aylesford 7294 (2 lines). *Telegrams :* Research, East Malling.

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Telephone : Aylesford 7294 (2 lines).

EDITORIAL

The Annual Report for 1940 has been arranged on the same general lines as in former years and the more recent improvements introduced in 1938 maintained. However, every effort both in editing and printing has been made to economize in space.

The general reviews of research in Section II have been confined to the most important items of progress during 1940 ; only those summaries of papers published in other journals have been included which record a particularly important stage in the work to which we wish to draw the attention of our Members.

Whilst we apologize for the unavoidable delay in the publication of this report, it has once again enabled us to give a complete picture of the farming year in Section I, and we have brought right up to date all changes in staff.

The general editorship of this Report has once again been undertaken by Dr. Wormald, and Mr. N. B. Bagenal has helped in the assembling of Sections II and IV. As usual the heads of Sections are responsible for the Sectional Reports.

R. G. Hatton.

August 1941.

Section I

THE EXPERIMENTAL FARM

Contributions from J. AMOS, F. H. BEARD, R. G. HATTON, T. N. HOBLYN and H. B. S. MONTGOMERY

In the last report, we gave a bird's eye view of the Experimental Farm as a whole and detailed the acreages devoted to individual crops. This year we have decided to stress the particular problems in relation to those crops during the year 1940. Since weather conditions played such an important part we would ask our readers first of all to study "Weather Conditions during 1940," Section III, page 44.

Experimental Orchards.—Top Fruits.—*Apples.*—The total apple crop on the whole 50 acres amounted to some 10,000 bushels as against 15,000 in 1939. While it was undoubtedly a second year of heavy cropping, the crop as a whole was undersized. This is attributable to several causes. Owing to our preoccupation with so many other operations, such as strawberry picking and plum thinning, most of our apple crop was left unthinned. We had considerable droughty periods, and very general and severe attacks of Red Spider and Capsid Bug, as noted later. Very little bulky organic matter has been available for the apple plantations in recent years. The outstanding yield of the year, per acre, was Barnack Beauty with 532 bushels; Cox's Orange Pippin came a good second with just over 325 bushels per acre—this area included a considerable number of 2 and 3 year frame-worked trees and those in the nutritional "deficiency" plots. Our Bramleys worked out at rather under 300 bushels an acre and Lane's Prince Albert only just over 200. While the best Worcester Pearmains averaged about 4 boxes a tree, the total yield was under 200 bushels per acre. This was partly due to the difficulties of harvesting and a consequent heavy drop.

When we came to consider the problem of winter pruning for 1940-41, it was obvious that most varieties had practically ceased leader growth and that there was a definite shortage of well-developed fruit buds. Nearly all varieties had their spurs shortened back and thinned out. Lane's Prince Albert which had cropped heavily continuously since 1935 was severely "dehorned" in addition. Whilst the Bramley's were neither spur pruned nor dehorned, branches and lateral growths were heavily thinned.

Pears.—Off the 7 acres, consisting of 23 varieties, approximately 2,000 bushels were harvested for the second year in succession. The fruit, like the apples, was on the small side. An acre of Conference produced 475 bushels, and 2 acres of Dr. Jules Guyot—including one acre on clonal free pear stocks—yielded 445 bushels. For the second time in 19 years the Pitmaston Duchess gave a crop. A number of trees of Reine des Poires, in the year after frame-working with Laxton's Superb and Williams' Bon Chrétien, bore about ½ bushel of fruit per tree. Emile d'Heyst yielded at the rate of nearly 300 bushels an acre and Durondeau nearly 250.

In view of the irregular cropping and comparatively poor quality of Dr. Jules Guyot on free pear stocks, a trial to test the effects of "dehorning" and branch thinning was initiated at pruning this winter, whilst the long laterals on the frame-worked Superbs and Williams were worked back with a view to increasing fruit size.

Plums.—The outstanding crop of the year was plums. There are 11½ acres in 24 varieties on the farm in cropping and the heaviest total crop previously amounted to 5,450 halves (58 tons) in 1936. In 1940 some 10,500 halves (113 tons) were marketed, 7,900 halves went for canning purposes and 2,600 were sold in chips and halves on the open market. The crop was so thick that the only chance of growing Victorias of dessert size was to thin heavily. But Czars and Yellow Egg plums were also thinned to save the trees from breaking down. Even then they subsequently required "shoring up". As a result the crop was an expensive one to grow and the prices, owing to the general glut, were very low, and it is doubtful whether, apart from relieving the trees, the operation of thinning was justified. Whilst a few extra selected Victorias made up to 2s. 6d. per 12 lb. chip on the open market, the bulk of them ranged from 1s. 6d. to 2s. From this the cost of grading, of non-returnables, of transport and of all market charges must be deducted. Delivered straight into an adjacent cannery in its containers the same weight of ungraded fruit made 1s.

The heaviest crop was from 3 acres of 10-year-old Giant Prune from which 3,600 halves were harvested—approximately 6 halves per tree. Three acres of Victorias, varying from 8 to 20 years old, yielded 1,700 halves of plums, or about 3 halves per tree, while approximately 2 acres of Czars, half of which formed windbreaks, gave 1,700 halves.

Twenty-year-old Early Rivers averaged nearly 6 halves per tree, 13-year-old Cambridge Gages gave about 4½ halves per tree, and Pershore Yellow Eggs about 6 halves. The other very

heavy crop came from Red Cherry Plum. Twenty-five 20-year-old trees and 240 10-year-old trees, all used as windbreaks, gave approximately 740 halves and, apart from Laxton's Early Gage and Ontario, fetched the highest prices of the season. Of the lesser grown varieties Oullins Golden Gage, Jefferson's Gage and Ontario sold best. The last mentioned appears to be a regular and heavy cropper and to deserve wider trial for commercial purposes. It is a largish yellow plum, of gage-like appearance, ripening in August, and is sufficiently well flavoured to be marketed as a dessert plum in its season.

Although our old favourite Warwickshire Drooper averaged $6\frac{1}{2}$ halves per tree, it suffered most severely from drought and red spider and the fruit never properly matured.

Despite the precautions taken, the heavy crops often caused serious branch breakage which added to the subsequent pruning, reduced the bearing area, and laid the trees open to Silver Leaf infection. Although we managed to pick this very heavy crop of fruit despite labour and seasonal difficulties, inevitably there remained here and there a residue of overripe plums which later in the season developed brown rot and called for the subsequent picking off of these mummied plums.

Cherries.—From the 6 acres of standard sweet cheeries approximately 460 halves were picked. Most of these came from the older trees in the variety collection and this was actually the biggest crop yet harvested. Like our other crops they felt the drought and the fruit was generally small.

An acre of bush Morellos yielded approximately 300 halves and the $\frac{3}{4}$ acre of Kentish Reds only 93.

Small Fruits.—*Strawberries.*—The 10 acres of fruiting plants of the East Malling "mild Crinkle" clone yielded 16 tons in their second year from planting. The 6 acres of this which had been autumn planted—which were allowed to fruit the first season—gave 2 tons per acre. The 4 acres of spring planted ones—and this was the third successional planting of strawberries on the area—gave a ton. Both fields looked much more promising at blossoming but the season was a very short one and the July rains came too late to save the crops. The quality of the berries was highly commended.

Raspberries, Loganberries and Blackberries.—All the cane fruits were down in yield compared with 1939. Whilst the drought was partly to be blamed, the Loganberries had suffered very severely from the winter injury of 1939-40. Not only were a large proportion of the canes killed outright, but those which remained grew weakly and produced poor quality distorted fruit.

Black Currants.—The 5 acres of the four main varieties and the 1 acre of Wellington's XXX yielded $4\frac{1}{2}$ tons. A large proportion of the blossoms never developed properly, and it was thought that this again was due to winter injury caused by the low temperatures in January.

The variety collections of Red Currants and Gooseberries generally yielded well.

R.G.H., T.N.H. and J.A.

Experimental Nurseries.—*Rootstock Stoolbeds.*—(Area under cultivation about 7 acres.) Early in the year 3 acres of established stoolbeds were grubbed. There was an increased demand for rootstocks at the end of the year and, in response to requests from the Ministry and the trade, urging the maintenance of sources of true-to-name rootstocks, it was planned at least to replant this acreage and to provide for its possible ultimate expansion. Ten acres of suitable land, recently acquired at Bradbourne, carrying 5 acres of strawberry runners and 5 acres of de-runnered maiden strawberry plants, has been earmarked for the purpose. The 5 acres containing the runners was cleared at the end of the year and plans laid to plant immediately 3 acres with re-selected clonal rootstocks in general commercial use. With the other areas of stoolbeds on the Station it is hoped to maintain a constant 10 acres of rootstocks in full bearing. When in full production, with the bedded rootstocks transplanted for one year elsewhere, such 10 acres should yield half a million rootstocks each year.

In order to hasten the production of re-selected clonal apple rootstocks a block of maiden trees on Newgates field, covering three-quarters of an acre, worked upon the rootstocks Nos. I, II, IV, VII, IX and XVI, was cut down below the grafts to produce a crop of rootstocks at the end of 1941. It is thus hoped at least in part to meet the rootstock shortage which is bound to come at the end of the war. In 1939 the Station was only asked to distribute 130,000 rootstocks, but in 1940 the figure rose again to 260,000. Even so a considerable proportion of our total yield had to be destroyed. It is interesting to note that 63,000 rootstocks were shipped safely to Canada during the year.

General Nurseries.—(Area under cultivation about 8 acres.) Nearly 6 acres were occupied by maiden and 2-year trees most of which were intended for the planting of large scale trials. The planting of these trials having been postponed the trees were cleared from 2 acres and the land made available for a food crop. A further three-quarters of an acre, as already mentioned, were cut down to form a temporary stoolbed and the bulk of the remainder were given the minimum treatment for the production of trees suitable for ordinary commercial planting.

Other than a few thousand black currant cuttings, covering about one-eighth of an acre, no bush fruits were planted. Small areas of red currants and gooseberries were retained for stock purposes. Less than a quarter of an acre of raspberries, loganberries and blackberries were planted in the nurseries during the year.

Strawberry Runners.—(Area under cultivation 14 acres.) Approximately 8 acres were occupied by the Royal Sovereign 1935 clone, and 1 acre by the Royal Sovereign 1940 clone. In addition 5 acres were de-blossomed and de-runnered in order to produce their first crop of runners in 1941. A few requests, for comparatively large quantities of runners, were received during the summer but it was not until the end of the lifting season that a heavy demand was experienced and it was found that the demand was somewhat greater than the supply. About 350,000 plants were raised during the season.

It was planned to reduce this area by about half in 1941 and action had been taken accordingly. But as this report goes to press the Station has been urged to increase its area of runners again, since the small-fruit area in the country is to be maintained at its present acreage provided approved plants are available. At present there is a great shortage of these.

R.J.G.

Hops.—Nine and a quarter acres are under hop experiments. Apart from the $\frac{1}{2}$ acre of selected Fuggles and a $\frac{1}{4}$ acre of virus-free Golding varieties, the whole area is occupied with new varieties from the South-Eastern Agricultural College, Wye. Some $2\frac{1}{2}$ acres of these varieties consist of six selections (including Brewer's Favourite, Quality Hop, and Fillpocket) grown in bulk for large scale brewing tests. They are also used in various cultural investigations relating to cutting, pulling, training, stopping, etc. Five-and-a-half acres are still occupied by 15 hill plots of some 200 new seedlings. These gardens are always in a state of flux, less valuable varieties being grubbed and new ones taking their place. As a result $1\frac{1}{2}$ acres are not at present in full cropping. Owing to drought conditions yields of nearly all varieties were reduced and many of the late hops of the New-Mexican type were so seriously checked that the cones never developed. As a result our total growth only amounted to slightly over $5\frac{1}{2}$ tons (nearly 8 tons in 1939).

Downy Mildew was not troublesome at any period and aphis was readily controlled. Some Red Spider was present, mainly on young hills which had not had the lower leaves removed.

Owing to the prevailing conditions it was never possible to obtain full oastings and in consequence our drying operations were less satisfactory and more costly than usual.

F.H.B.

Arable Crops.—*Potatoes.*—In view of the food situation, as much ground as possible was cleared of nursery material and strawberry runner beds. In consequence, it was possible to plant 10 acres with Arran Banner potatoes. These yielded 10 tons to the acre over the whole area. In view of the probable shortage of virus-free seed these were inspected by the Ministry of Agriculture and certified as suitable.

R.G.H. and J.A.

Trials of Seed Potatoes.—As a considerable acreage of potatoes was being grown at the Station, it was decided to apply a small part of it to the examination of some of the problems connected with "cut" seed. The prospect of a serious shortage of Scotch and Irish seed potatoes in the spring of the year led to a revival of interest in the cutting of seed prior to planting. The investigation was confined to the comparison of the yields from whole potatoes of "ware" and "seed" size with "ware" seed cut in half and either planted at once, or previously healed under varying conditions of temperature and humidity. Two varieties were used, Arran Banner, selected as a variety which responded readily to cutting, and Majestic, usually considered as difficult to "cut" successfully. The latter variety was obtained from two sources.

The investigation was carried out in collaboration with Dr. F. C. Steward and Mr. K. Wilson of Birkbeck College, who made a detailed physiological study of the tubers during the process of healing and subsequently after planting in the field. It is not proposed to describe these investigations here, but the effects on the final yields may be briefly commented upon.

In the Arran Banner experiment, the yields from whole "ware" and "seed" potatoes, the former being approximately double the size of the latter, were compared with "ware" tubers cut in half and planted immediately, and with similar cut tubers previously healed by three different processes. While the uncut tubers started into growth sooner and developed more bines to a plant, there was eventually very little difference, either in the total crops from the six different kinds, or in the proportions of "ware", "seed" and "chat" potatoes. The average yield was just over 14 tons to the acre, about $12\frac{1}{2}$ tons of which were classed as "ware". In the experiment with Majestic, only one method of healing was employed, but seed from two sources (A and B) was compared. This comparison was somewhat complicated, since, when received, the seed from source B was apparently contaminated with spores of Potato Dry Rot (*Fusarium oxysporum*). When the seed was cut and placed in the comparatively warm moist atmosphere necessary for the healing process, large lesions developed on the surface and many half tubers became wholly rotten. This treatment was, therefore, a complete failure, many "sets" failing to grow at all. On the other hand, where the similar tubers were cut and planted immediately, the disease did not develop sufficiently to prevent normal growth. Seed from source A seemed to be quite clean and, under the same healing conditions, no disease

developed. Apart from this factor of disease, there was again no difference in the yields from whole "ware" and "seed" potatoes and from the "cut ware", whether healed or planted at once.

Whole "ware" and "seed" sized potatoes and "ware" potatoes cut and planted at once from source A averaged $14\frac{1}{2}$ tons per acre, of which 9 tons were of "ware" size, while similar tubers from source B produced just over 13 tons per acre, of which, again, 9 tons were "ware". Thus source B gave a smaller crop, but a rather higher proportion of "ware" potatoes. T.N.H.

Bradbourne Land.—Of the 78 acres taken into occupation 30 acres were ploughed up and sown to Victor wheat and 17 acres to Victory oats. The former yielded $4\frac{1}{2}$ quarters per acre and the latter 8 quarters.

The 11 acres of seeds was cut for hay and the land prepared for a potato crop. Of the 10 acres planted up with the 1935 clone of Royal Sovereign, 5 acres was used for runner production and the other 5 de-blossomed and de-runnered for the 1941 runner crop. Of the remaining 7 acres of grass, 5 were ploughed up and sown to Victor wheat. The 2 acres around the house were retained for grazing.

The Bradbourne gardens were once again used as isolation centres for the production of clonal disease-free strawberry runners and Golding hops. R.G.H. and J.A.

Routine Spraying Programme.—In many ways the season under review was a difficult one in which to control pests and diseases. There was a general shortage of skilled labour on this farm as on other farms, and this inevitably led to certain sprays being delayed and the efficiency of the control being reduced. Coupled with this state of affairs the weather conditions were far from favourable at some of the critical periods. On the whole the spraying followed the same routine as in previous years but certain departures from the normal schedule warrant some comment.

The winter washing with tar-oil emulsion was started at the beginning of December but, owing to the prolonged spell of frost and snow which held up operations, it was not finished until the end of February. On account of the lateness of the application, the Morello cherries were sprayed with normal strength tar-oil, instead of the double strength as in previous years for Brown Rot control. Several small plots of plums had to be omitted altogether as they were not sprayed before growth began, and these were sprayed in May with nicotine and soap to control Aphis.

High winds and rain made it impossible to apply the Capsid spray of petroleum oil on more than a few of the apple plots. On these plots the spray was so late that it was considered unwise to follow up with lead arsenate and lime-sulphur at green-bud stage and a flotation sulphur alone was used instead. All plum plots with Red Spider during the previous season were successfully sprayed with petroleum oil. As it had not been possible to use petroleum oil on the main bulk of the apple trials nicotine was included in the pink-bud Scab spray to control Capsid. The control was not good, especially where the trees were rather crowded.

In general lead arsenate was put in the green-bud spray, except where petroleum had been used, and little trouble was experienced from caterpillar. One or two of the plots and the windbreaks, mainly Cherry Plum trees which are usually left unsprayed, did develop sufficient caterpillar to make it necessary to spray them with lead arsenate.

Hot weather about a fortnight after petal-fall made it seem advisable to omit the lime-sulphur spray normally applied to apples. In omitting this spray the risk of Red Spider was fully realized but at the time this pest was not numerous. Unfortunately the hot dry weather persisted and the pest rapidly multiplied till it reached serious proportions. An attempt was therefore made during the first week of July to check the Spider with "safe" sprays as follows: $\frac{3}{4}\%$ lime-sulphur and spreader, flotation sulphur (0·4%) and spreader, and a Rotenone-containing spray and spreader. None of these sprays proved effective and this pest caused considerable damage to the leaves.

The pears remained fairly clean with one pre-blossom spray, between green- and white-bud stages, and a petal fall spray. This control of Scab was undoubtedly assisted by the hot dry weather.

The first pickings of raspberries and loganberries showed a rather high percentage of larvae of the Raspberry Beetle indicating that the Derris spray was applied a day or so late in each case. Subsequent pickings were quite satisfactory in this respect.

All strawberries were dusted with flowers of sulphur for mildew at the end of April, but only the runner beds were dusted again in mid-July. If it had been possible it would probably have been worth while dusting the fruiting plants also at this time as there was quite a bad attack of mildew on new growth late in the summer.

The hops were sprayed twice in July with Bordeaux mixture ($5\text{-}7\frac{1}{2}\text{-}100$) plus 6 pints cottonseed oil and 6 oz. nicotine. Certain late varieties received a third spray in the second week of August but the earlier varieties were too far advanced. These sprays kept the crop free from Downy Mildew.

From time to time various plots required special treatments in connection with particular experiments and these all added to the work for machines and men throughout the season.

H.B.S.M.

Section II

GENERAL REVIEW OF RESEARCH WORK

WITH LISTS OF PAPERS PUBLISHED DURING THE YEAR

I. POMOLOGY

Contributions from the Pomology Staff, collected and edited by R. G. HATTON and W. S. ROGERS

A.—Tree Fruits.—Observations on the main bush and half-standard apple trials showed differential response of the same varieties upon *different rootstocks* to interveinal leaf scorch generally attributed to magnesium deficiency. (E173.)

The marked influence of different rootstocks upon the vigour and cropping of Cox's Orange Pippin and Worcester Pearmain grown as *cordons* was observed in 1940, as were also the effects of different distances of planting and times of pruning.

The comparative trial of Lane's Prince Albert on 13 *clonal rootstocks selected from "Free" and "Crab" seedlings* at Long Ashton has been reviewed after 14 years. The series was compared with trees on commercial Crab Seedlings and showed a similar wide range of vigour, but two of the rootstocks were partially "incompatible". None of these selections nor the trees on seedling roots, grew as strongly as those on the "very vigorous" East Malling clones, i.e. No. XII, A and C. Two of the Long Ashton rootstocks showed considerable promise for moderately vigorous and semi-dwarfing heavy cropping trees, for which purpose they deserve further trial. These conclusions very generally confirm the Long Ashton results with different varieties on the same rootstocks under conditions in the West. (E165.)

The *studies of the anatomical structure of the stems and roots* of some clonal and seedling rootstocks of a series of stem- and root-grafted trees, planted above and below ground, have yielded some important results. (See page 19.)

The behaviour of the various *gages upon different rootstocks* is being closely followed on young trees. There were further indications of the special stock requirements of Oullins Golden and Comte d'Althans gages, and of the widely different potentialities of different varieties of *Prunus cerasifera* (Myrobolan) rootstocks. "Compatibility" trials of peach and apricot varieties are yielding interesting results in the nursery. (E170.)

The 15-year-old standard sweet cherry orchard upon *clonal Mazzard rootstocks,* is beginning to fruit. Rootstock influence upon time of blossoming, quantity, quality and size of fruit as well as upon vigour is becoming evident. There are unwelcome indications that one otherwise very desirable rootstock may have a propensity to "sucker". (E167.)

Many new and untried rootstocks—apple, pear, quince, plum and cherry—have been undergoing propagation tests. A rigorous selection will be made this winter.

A successful technique for hastening and cheapening the operation of double-working of pear trees has been worked out on Williams' Bon Chrétien and a description published. (Eg20.)

The mature trees of Czar and Purple Egg plums framework-grafted in 1938 with a series of gages and late-keeping varieties yielded a first crop in 1940. So far only one variety, Old Transparent Gage, has exhibited distinct signs of incompatibility with Czar by breaking out at the union, though the growth appeared satisfactory in the first two seasons.

Many Lane's Prince Albert and a collection of different *apple varieties frame-worked* to Cox's Orange Pippin in May 1937 bore a first crop, and some of the Gladstones similarly frame-worked to Worcester Pearmain had a few fruits. These methods of rapidly converting unprofitable trees are proving of real commercial importance.

The history of *two apple manurial trials* from 1920 to the end of 1939 has been reviewed for publication. Four representative varieties on a range of clonal rootstocks have shown that nutritional requirements vary with different varieties and with the same variety on different rootstocks. At the Station regular dressings of potash fertilizer appear necessary, but there is as yet no evidence of any need for phosphatic fertilizers. The amount of nitrogen required has varied with the variety, the rootstock, the method of cultivation, the age and the cropping of the trees. The balance of nitrogen and potash must be carefully maintained for, if upset, not only may a deficiency of one or the other affect the trees, but further deficiencies may appear. Thus interveinal scorch—symptomatic of magnesium deficiency—was only severe on trees with a low nitrogen/potassium ratio. Trees on East Malling rootstocks Nos. I, IV and VII were particularly susceptible to interveinal scorch, but those on Nos. IX, II, V and XII were notably resistant. (E173.)

While these manurial field trials are being continued, the problems naturally change with the age and condition of the trees. On the oldest trial the residual effect of 8 years' high potash dressings on Bramley's Seedling and the value of soil applications of magnesium sulphate on interveinal leaf scorch are being studied.

The trial of inorganic fertilizers on Cox's Orange Pippin and Beauty of Bath is being continued, but has been modified and includes a scheme for investigating how far lack of organic matter in the soil may account both for the poor mechanical soil condition of this plantation and for the poor performance of many of the trees. During 1940, the trees originally potash-starved continued to show a marked response to the annual dressing of 2 cwt. sulphate of potash, which has now been given for 3 years. The other interesting development was the severe outbreak of "ghost flowers"—flowers improperly formed and without pigment—especially on Beauty of Bath. The intensity of the trouble varied too with rootstock, nutritional treatment, and location. Many branches showing the trouble became œdematous (supersaturated) and subsequently died. No parasitic organism was found. This suggests that nutritional and climatic factors are responsible.

Progress has been made with the programme designed to show whether the *use of humus-producing cover crops* can maintain the organic matter content of the soil, and replace the use of costly imported organic manures. (See Section IV, page 83.)

Water usage studies of certain cover crops have been begun. Periodical humus and nitrogen analyses are being made with the collaboration of Wye College.

The soil moisture conditions amongst various crops have been followed throughout 1940 by means of soil moisture tensiometers, over 30 of which have been in use. The soil was unusually dry almost from June to October. The *irrigation experiment* originally planned to observe the effect of abundant water on the June drop of pears was repeated and continued until the fruit was ripe. These experiments gave no evidence that the June drop was due to lack of moisture, but the irrigation probably increased fruit size and caused poorer keeping quality.

Pruning experiments on mature apple trees are being directed mainly towards the maintenance of regular crops of good fruit and to the reduction of biennial bearing.

It has been observed that the spring frosts of 1938 have greatly modified the performance of trees previously regularly biennial. The investigations have been developed on a new series of trees, and the treatments include the rubbing out of fruit buds in the "on" year, and very late (end of May) "off" year spur shortening.

Further investigations on *low temperature injury* to apple blossom made in a temperature-controlled chamber at the Ditton Laboratory with Cox's Orange Pippin flowers, showed no correlation between damage to flowers and treatment with lime-sulphur spray at any of the three concentrations 5%, $2\frac{1}{2}$%, and 1%. However under these conditions, it must be emphasized that no spray damage to the surrounding leaves occurred. Nor were flowers which were wet with spray when exposed to freezing more susceptible than those allowed to dry after spraying before exposure to low temperatures. In all except one instance glycerin-sprayed flowers were less severely damaged by low temperature than non-sprayed ones, although generally resistance decreased with increasing lapse of time after spraying.

The severe winter weather conditions of 1939-40 resulted in much winter injury to the trunks and branches of many fruit trees by causing severe bark splitting, and in some cases death of branches and whole trees. The opportunity was taken to make detailed observations upon the incidence of the trouble in various parts of Kent as well as the Research Station. Certain measures for the amelioration of the damage, based on accepted Polish practice, were tested, but final conclusions cannot be drawn before 1941. Generally speaking the winter injury was confined to certain varieties, though age, condition of trees, and location were important factors.

After 19 years observation, *apple varieties* showing no commercial promise have been top-grafted either to the most promising dessert or to very late blossoming sorts which might be worth growing in areas subject to spring frosts.

The collection of dessert plums and of late ripening varieties frame-worked upon mature trees of Czar and Purple Egg began to fruit in their second year and bore a useful crop in 1940.

The good cherry crop of 1940 was used, as far as time allowed, to check previous descriptions and suspected synonyms.

Fan-trained trees of six varieties of black acid cherries (Morellos or Griottes) all on the vigorous Mazzard stock F12/1 have been prepared in 1940 for planting against the north and east walls at Bradbourne.

The 820 *new seedling rootstocks* showing a high degree of resistance to Woolly Aphis differed widely in the readiness with which they formed adventitious roots and in other propagation characters. A report (E168) dealing with this has been published. Rooted stocks from most of these seedlings have been sent to the United States Department of Agriculture for parallel trials. Two hundred and fifty-eight of these rootstocks, after growing for three seasons worked with Lane's Prince Albert, are

showing differences in vigour. A report on the classification and selection of these rootstocks appears in Section III of this Report (see page 32).

A report on the trial of immune rootstock seedlings, Merton Nos. 778, 779, 789 and 793 with Lane's Prince Albert, in its sixth year, has been published (E169). It is shown that trees on these four immunes fall into an intermediate class for vigour and precocity, but are all more vigorous than those on Spy rootstock.

Several seedling pears selected as ready rooters from batches of imported wildings and some wild pear and quince seedlings from the Caucasus are still undergoing propagation and compatibility trials.

Many of the 2,000 apple seedlings raised between 1929 and 1939 with the object of obtaining *improved varieties* of high quality and extended season, are now fruiting. Several have been selected for more extensive trial. A study is being made of the inheritance of many characters. Of several hundred pear seedlings raised during the past few years to produce improved varieties for commercial use, a few began to bear fruit in 1940.

Studies on the effect of different pollens on the size and other characters of the fruit in apples and pears are showing differences which may be important.

B.—Small Fruits.—The year 1940 was an exceptionally good one in which to study varietal susceptibility to "Cane Blight" in *raspberries*. As in 1939 "Cane Blight" seriously injured several varieties, particularly Newburgh. Of this variety, the few surviving canes, which were all small, produced a light crop of poor fruits; even the dessert quality of the fruit seemed poor by comparison with previous years. Two other American varieties, Viking and Herbert, and the German variety, Preussen, were also considerably injured. The newest American varieties, Taylor, Marcy and Indian Summer, however, seem up to the present more resistant to Cane Blight. Of British varieties few were more than slightly injured though every one examined showed at least traces of the disease.

New clones of several *strawberry varieties*, including Royal Sovereign and Paxton, now under test, give promise that strains of proved cropping capacity free both from Yellow-edge and from Mild Crinkle virus will soon be available in quantity.

In the *propagation* section an effort has been made to maintain nuclei of healthy races of the most important varieties of small fruit. The raspberry propagation plots are now in condition to produce several thousand canes annually, comprising some 20 named varieties and 17 new selected seedlings. A third plot was established in the winter of 1939-40 at Bradbourne, with one named variety (Norfolk Giant) and two of the best seedlings. There is here ample room for extension in a well-isolated situation.

Tip layering and leaf-bud cutting propagation methods have been further studied for Blackberries, Loganberries and other hybrid berries, and a desirable clone of Loganberry has been established.

Large scale runner beds of Royal Sovereign strawberry have been maintained in isolated positions, and have given satisfactory results both in health and productiveness, in spite of a dry summer. New methods of runner-laying have been tried, but the square block originally recommended still seems as good as any.

In the *breeding work* a cropping trial of black currants with seven selections from crosses between commercial varieties yielded very heavy crops from several seedlings. Of the 1939 raspberry seedlings some 120, belonging to three families, are entirely thornless, and may include some forms of commercial value. One family (germinated in 1937) produced by crossing Newburgh with an earlier seedling, shows many promising forms, some of which have now borne fruit for 2 years, of a size, colour and firmness not previously seen here in combination. From all the families raised some 110 selections have been propagated for further observation. Although all these have shown promise, the many characteristics which must be combined in a good commercial variety make it certain that few will finally be retained. In the search for strawberry varieties of high quality, that are either easily rogued for virus or are virus tolerant, several hundred selfed seedlings of Royal Sovereign, Sir Joseph Paxton and King George, raised from virus-free parents, have been planted in isolation at Bradbourne. It is hoped to select from them parents suitable for intercrossing. For the same purpose clonal plots of selected hybrids between *Fragaria chiloensis*, *F. virginiana* and *F. vesca* have been planted out for fruiting.

On *the cultural side* a comparative trial of clonal Loganberry and Phenomenal Berry, grown under different training and spraying treatments for the control of Cane Spot disease, has revealed important economic differences. (See Section IV, page 89.)

Strawberry plants de-blossomed in their first year cropped more heavily than those allowed to fruit in their first year; and plants from one-year-old parents cropped more heavily than those from two-year-old parents.

Irrigation experiments were made on strawberries and raspberries, with an oscillating overhead

equipment. In strawberries both amount and size of fruit was increased, though less than expected. In raspberries some varieties showed an increase and others did not. In view of the dry conditions, this lack of larger response is surprising, and suggests that optimum soil moisture conditions and irrigation technique require further study.

C.—Walnuts.—The winter of 1939-40 was an exceptionally good one for testing the winter hardiness of the many walnut varieties now growing on the Station. With two exceptions, trees of all varieties and ages survived the severe conditions. In November 1939 most of the best seedling *Juglans regia* and *J. nigra* rootstocks were, as usual, potted up for subsequent grafting under glass. They were placed on an open bench without other protection. During the very low temperatures it became apparent that the plants and soil in the pots were frozen. Subsequently it was found that the majority of the roots below soil level had suffered the worst, and were mostly killed. The above ground portion of the stocks often appeared uninjured. The remainder of the seedlings which had been left in the seedbed outdoors were quite uninjured, as were all the young grafted trees from 1 to 3 years old, and a number of older trees which had recently been transplanted into their permanent quarters. A single 10-year-old tree of Meylanaise grafted high on a hybrid rootstock collapsed in the spring. Examination showed that the rootstock had died first, but whether as a result of winter injury is uncertain.

D.—Horticultural Meteorology.—A study of meteorological factors in relation to frost damage has been continued under a special grant. Results obtained near Malling in 1939 have been confirmed and carried further by a study of wind speed and temperature conditions in the Vale of Evesham in April and May 1940. Simultaneous observations of wind speed, cloud and temperature were made on relatively calm nights in two fields 3 miles apart, one on top of the Cotswolds and the other in the valley, using for the first time low-speed anemometers devised for the purpose. Under so-called "calm" clear night conditions the air speed in the valley averaged 1·3 m.p.h. and that on the hill 4·3 m.p.h. When speed of wind in the valley was less than 2 m.p.h., its temperature was lower in relation to hill air temperature than would be expected, after allowing for the normal temperature rise due to increased barometric pressure in the valley; conversely when speed of valley air exceeded 2 m.p.h., its temperature was higher than expected.

These new data give some guide to the air conditions under which orchard heaters would work in this and similar localities.

Publications during the Year

In Relation to Tree Fruits.

The Present Status of Research in Rootstock Plants and the Use of Rootstock Plants. R. G. Hatton. Presented at the XIIth International Horticultural Congress, Berlin, August 1938, National Report for Great Britain. Rep. E. Malling Res. Sta. for 1939 (1940), 37-41. (E144.)

Trials of Clonal Apple Rootstocks Selected from "Free" and "Crab" Seedlings. II. Performance at East Malling when worked with Lane's Prince Albert. T. N. Hoblyn. J. Pomol., 1940, **18**, 239-48. (E165.)

The performance at East Malling over a period of fourteen years of Lane's Prince Albert apple trees on thirteen clonal rootstocks, selected from "free" and "Crab" seedlings at the Long Ashton Research Station, is detailed. They are compared with similar trees on six East Malling vigorous clonal selections and on commercial seedling "Crab" stocks. The Long Ashton rootstocks induced a wide range of vigour comparable with that of the seedlings. All were less vigorous than most of the East Malling selections and two were at least partially incompatible with Lane's Prince Albert. At least three East Malling rootstocks are outstandingly more vigorous than the seedling rootstocks. Two of the Long Ashton rootstocks, G.7 and F.11, appear promising as heavy cropping, moderately vigorous and semi-dwarfing rootstocks respectively, and were it not for poor nursery qualities, a third, E.7, might also be recommended as a semi-dwarfing rootstock. The same disadvantage prevents the recommendation of the two East Malling "Crab" selections C and A, both of which have been outstanding as the producers of vigorous, heavily cropping trees.

A Résumé of the Cherry Rootstock Investigations. N. H. Grubb. Rep. E. Malling Res. Sta. for 1939 (1940), 41-44. (E167.)

Apple Rootstocks Immune from Woolly Aphis. II. The Testing in the Nursery of New Seedling Immunes. H. M. Tydeman. Rep. E. Malling Res. Sta. for 1939 (1940), 44-46. (E168.)

Apple Rootstocks Immune from Woolly Aphis. III. The Influence of four new seedling Immunes on Lane's Prince Albert. H. M. Tydeman. Rep. E. Malling Res. Sta. for 1939 (1940), 46-48. (E169.)

Maintaining the Soil in our Orchards. A Note to our Members. R. G. Hatton, W. S. Rogers and W. A. Roach. Kent Fmrs' J., 1940, **48**, 56; Market Grower and Salesman, 1940, **17**, 10, and Fruitgrower, 1940, **90**, 141-2. (E171.)

Les essais et la selection des porte greffes améliorés pour les arbres fruitières de plein air. H. M. Tydeman. Paper presented to Congress International d'Arboriculture Fruitière 1939. Translated into French by Mons. G. de Wilde, Conseiller d'Horticulture. Le Fruit Belge, 1940, 8me Année, No. **43.** (E172.)

An account is given of work carried out at East Malling on the testing and selection of improved apple, quince, pear and plum stocks.

Manurial Trials with Apple Trees at East Malling, 1920-39. T. N. Hoblyn. J. Pomol., 1941, **18,** 325-43. (E173.)*

The history of two apple manurial trials at the East Malling Research Station, from the time the trees were planted in 1920 up to the end of 1939, is reviewed. They have included four very different varieties worked on a range of clonal rootstocks and confirm the earlier finding that the nutritional requirements of different varieties vary, as do also those of the same variety on different rootstocks.

The nitrogen and potassium requirements of Bramley's Seedling and Worcester Pearmain were found in the earlier trial to be different. In the later trial Beauty of Bath was found to require a greater amount of potash than Cox's Orange Pippin, while the latter responded more readily to dressings of nitrogen. Trees of Bramley's Seedling on East Malling No. V rootstocks suffered more from potassium deficiency than those on No. I, but with Cox's Orange Pippin and Beauty of Bath the position was reversed. Cox's Orange Pippin and Beauty of Bath on East Malling No. IX deteriorated less rapidly, when subjected to potash deficiency, than when grown on other rootstock and recovered more quickly when the deficiency was remedied. Regular dressings of potash fertilizers appear to be needed by apple trees at East Malling. During the first ten years of the trees' life dressings of superphosphate have shown no clear effect, nor has the omission altogether of these dressings produced any symptoms of a deficiency of phosphorus in 20-year-old Bramley's Seedling trees. The amount of nitrogen necessary varies with the variety, the rootstock, the method of cultivation, the age and the cropping of the trees. This fertilizer must be carefully balanced with potash, for if this balance is upset, not only may the deficiency of one or the other be detrimental to tree performance, but further deficiencies may appear. On this East Malling soil, when a deficiency of potash is remedied, trees may show the interveinal leaf scorch symptomatic of magnesium deficiency; but if the nitrogen/potassium ratio is sufficiently high the scorch is much less severe. Trees on East Malling rootstocks Nos. I, IV and VII are particularly susceptible to interveinal scorch, but those on Nos. IX, II, V and XII are notably resistant.

Anatomical Studies of Stems and Roots of Hardy Fruit Trees. III. The Anatomical Structure of Some Clonal and Seedling Apple Rootstocks Stem- and Root-grafted with a Scion Variety. A. B. Beakbane. J. Pomol., 1941, **18,** 344-67. (E174.)*

Anatomical studies were made of transverse sections of the rootstocks of seventy-seven Lane's Prince Albert trees stem- and root-grafted on (1) East Malling clonal rootstocks Nos. IX, II and XII, and (2) seedlings from a commercial source. For two years the trees were grown in nursery rows with the union between rootstock and scion above ground level. At the end of this period the trees were lifted; some trees were sectioned and examined immediately and others were replanted, half with their unions at the same level as in the nursery and half with their unions below ground level.

Anatomical differences were observed between :—(a) Different clonal rootstocks whether stem- or root-grafted. (b) Different individual seedling rootstocks whether stem- or root-grafted. (c) The rootstocks and the scion variety. (d) Stem and root of the same rootstock when grown in their normal position as regards ground level. (e) Stem of the same plant grown above and below ground. (f) Root of the same plant grown above and below ground.

Rootstock No. IX had a small number of wood fibres, but a larger number of vessels, wood parenchyma and wood ray cells per unit area than the other two. The bark-wood ratio was high and the percentage area of fibres in the bark low. There was a relatively small area of fibres and vessels but a large area of parenchyma and rays in the wood, and the rays were very wide. The percentage area of living as compared with dead tissue was very high both in bark and wood. The wood fibres of No. IX were large and the vessels very small compared with those of the other rootstocks. The structure of rootstock No. XII differed greatly from that of No. IX. No. XII had a large number of wood fibres and a small number of vessels, wood parenchyma and wood ray cells per unit area. The bark-wood ratio was low and the percentage area of fibres in the bark high. There was a relatively large area of fibres and vessels, but a small area of parenchyma and rays in the wood, and the rays were not so wide as those in No. IX. The percentage area of living as compared with dead tissue was very low both in bark and wood. The wood fibres were small and the vessels very large. Rootstock No. II was intermediate between Nos. IX and XII in all these characters.

* E173 and E174 are included here for they were written and were in the hands of the publishers in 1940, though not actually published until January 1941.

The structure of the seedlings resembled that of No. XII in many ways, but was frequently intermediate between that of Nos. II and XII. The structure of individual seedling plants varied in some characters.

Tissue initially above (stem) and initially below (root) differed in the following characters :— the bark : wood ratio was lower and the percentage area of fibres in the bark higher in tissue initially above than in that below ; the number of wood fibres and vessels per unit area was greater and the size of the vessels and wood parenchyma cells smaller in tissue initially above than in that below ; the relative area of living to dead tissue in wood and bark together was also smaller. Tissue finally above (stem and root above) differed from that finally below (stem and root below) even more markedly. The number of wood fibres and vessels was greater and the number of wood parenchyma cells less in tissue finally above than in that below. The wood fibres, vessels and wood parenchyma cells were smaller and the percentage areas of wood parenchyma and wood rays were less however. The relative area of living to dead tissue in bark and wood was much less in tissue finally above than in that finally below.

Preliminary microchemical tests indicated that : (1) More starch may be present in rootstocks Nos. IX and II than in No. XII and in tissue grown below ground than in that grown above; (2) More fats and oils may occur in Nos. IX, II and XII than in the seedlings. (3) Nos. IX and II may contain more oxidases and peroxidases than No. XII or the seedlings. (4) Tissue grown above ground may contain more tannin than that grown below.

The Experimental Farm. Section I. R. G. Hatton, T. N. Hoblyn and M. H. Moore. Rep. E. Malling Res. Sta. for 1939 (1940), 13-19. (E175.)

General Review of Research Work with lists of papers published during the year. Section II. Rep. E. Malling Res. Sta. for 1939 (1940), 20-36. (E176.)

Studies in Nursery Technique. The Production of Double-worked Pear Trees. R. J. Garner and D. H. Hammond. Rep. E. Malling Res. Sta. for 1939 (1940), 84-6. (Eg20.)

Vegetative Propagation of Tropical and Sub-Tropical Plantation Crops. G. St. Claire Feilden and R. J. Garner. Imp. Bur. Hort. and Plantation Crops Tech. Comm., No. 13, March 1940, 99 pp. (Eg21.)

Horticultural Meteorology.

Weather Conditions during 1939. H. C. Chapelow and H. M. Tydeman. Rep. E. Malling Res. Sta. for 1939 (1940), 48-50. (H39.)

In Relation to Small Fruits.

Studies of Cultivated Varieties of Rubus and their Hybrids. II. Description and Selection of Clonal Races of some cultivated blackberries and hybrid berries, including loganberries. A. B. Beakbane. J. Pomol., 1941, **18**, 368-78. (Esf42.)

Studies of Cultivated Varieties of Rubus and their hybrids. III. A comparative trial of Loganberry and Phenomenal Berry plants grown under different methods of training and spraying to control Cane Spot disease. A. B. Beakbane. J. Pomol., 1941, **18**, 379-93. (Esf43.)

II. STATISTICS AND RECORDS

By T. N. HOBLYN

The first year of war has brought about a reduction in the many detailed records of growth and crop which have hitherto been obtained annually. It has been the business of the Statistical Section to ensure that the records taken are the best possible, taking into consideration the shortage of recording labour. When methods of estimation have had to be substituted for more accurate measurements, care has been taken that the methods used should be reliable and as free from observer's bias as possible.

During the year the first large scale manurial trial of apples planned in accord with modern statistical ideas has been reviewed (see I. Pomology, page 19). From the statistical point of view much has been learned from this trial about the experimental design of field trials with fruit trees. Although the arrangement of the plots in randomized blocks was adequate for its original purpose, the need for a rather greater elasticity in design and the provision for developments and modifications in the treatments during the long life of the trees has now been realized. Possible future contingencies are therefore now being considered in planning all long term field experiments.

A trial of selected clonal rootstocks compared with commercial seedling rootstocks also reviewed,

has clearly shown the need for a special experimental design in any comparison of tree variability. (See also I. Pomology.)

Two statistical studies carried out in collaboration with members of the Entomology Section have been reported on. On the basis of a study of the incidence and statistical distribution of the Strawberry Aphis, *Capitophorus fragariae* Theob., a sampling technique for the comparison of infestations in commercial plantations has been recommended. While this method is adequate for fairly high infestations, particular attention is now being given to the more difficult problem of comparing infestations where the numbers present are very low. A critical examination of the measurements of the principal organs of at least 30 specimens of each form of *Macrosiphum rubiellum* Theob., and of *Aphis idaei* Van der Goot, revealed that the ratios of lengths of organs were unstable characteristics of the species examined. A method was given for assigning limits of variation within a species. (See also VI. Entomology.)

One of the more difficult aspects of the analysis of the records of long term experiments is the problem of missing trees or plots. In some instances, particularly where diseases such as Apple Canker, Bacterial Die Back, or Silver Leaf are not effectively controlled, the mortality is serious. Where this is so, especially in complex experiments, statistical analysis is greatly complicated. Special attention is being paid to methods of dealing with such experiments with the object of extracting the maximum amount of information from the records of the trees which remain.

Several studies, such as the effect of light intensity and manurial treatment on growth, fruit bud differentiation in pears, rooting of hardwood cuttings, the measurement of, and variation in climatic factors in the investigation of conditions on frosty nights, and the regularity of growth of cereals through the season have been carried out by postgraduate students and guest research workers at the Station. In all of these statistical problems have arisen, some of which have widened the experience of the Section.

Publications during the Year

See Pomology E173 and E165, and Entomology D142.

III. PLANT PHYSIOLOGY

By M. C. VYVYAN

Vegetative Propagation.—A further census of rooting performance in a layer bed of a shy-rooting plum stock was taken in the autumn of 1939. This and previous censuses show that the number of rooted shoots was relatively greater on short layers than on long, and in regions near the base of parent plant than further away. Shoots from buds on the under surface and sides of layers rooted better than those from buds on the upper surface. Experiments showed that rooting performance can be improved without reducing the total number of shoots, by shortening layers to about 2 ft. and by rubbing out certain buds. Plants with shortened layers could be placed closer together thus economizing space in the nursery. Treatment of layers with indolebutyric acid in lanolin paste did not give hopeful results.

The results of numerous experiments on cuttings, carried out in 1939-40 and the previous season, show that rooting performance is much influenced by the source of the material, the portion of shoot used, etiolation of the base of the shoot and by treatment with the synthetic growth substance indolebutyric acid. The response varied with the variety and there was sometimes marked interaction between the effects of various factors. In one variety a hedge proved the best source for material. The basal portion of shoot rooted best in hardwood cuttings that included the etiolated base; its effect on those taken from the middle portion of the shoot varied with the variety; in one it improved rooting, in another it depressed it. There was little difference between the effects of indolebutyric acid and those of its potassium salt, whether these were injected into the cuttings in the dark, or in the light, but there was some indication of varietal differences in response. Medium concentrations sometimes reduced rooting.

Production of Natural Hormones in Plum Stocks.—The new constant temperature and humidity room has been used to examine the production of natural hormones in plum stocks and its relation to rooting performance. The delicate "coleoptile test" method was used.

Growth of Apple Trees in Water Culture.—The results of the 1938 experiment have been published (F34). Variability of trees was reduced by growth in water culture. The characteristic effect of stock on scion growth was not affected, but blossoming was as great on the vigorous as on the dwarfing stock. Taking the season as a whole, the amounts of K and N absorbed by trees on the two stocks were more or less in proportion to their respective growths. Absorption of K, however,

during the early part of the season, was greater on the more vigorous stock. The trees were grown on into 1939 and set a fair crop.

Physiological Disorders of Rubi.—(In collaboration with Pathology.) The causation of dwarf lateral scorch of raspberry and dieback of loganberry and blackberry by mild winters, and their possible control are being investigated. Canes were kept at 40° and 31° F. for various periods during the winter, and some were sprayed with linseed oil emulsion and others with sodium thiocyanate solution.

Diagnosis of Mineral Deficiencies.—(In collaboration with Biochemistry.) An investigation has been begun to find the best method of sampling the foliage of apple trees for the diagnosis of mineral deficiencies by spectrographic analysis.

Light Intensity below Trees.—(In collaboration with Pomology.) The light intensity below trees was measured with a view to correlating it with the growth made by cover crops. Observations were made beneath trees of different ages and varieties, both when the leaves were partly expanded and when mature.

Reduction of Pre-harvest Fruit Drop.—Experiments are being carried out to determine the effect of spraying with alpha naphthalene acetic acid, on the drop of apples just before harvest. Considerable reductions in drop were achieved in 1940 with concentrations of $2\frac{1}{2}$ to 5 parts per million, both when the substance was used alone and when it was mixed with oil.* These experiments are being continued.

IV. BIOCHEMISTRY

By W. A. ROACH and B. D. BOLAS

Work has been concentrated on using existing plant injection and plant analysis methods for giving a "running commentary" on the nutritional status of trees of known history on the Research Station and on applying them to practical problems in commercial plantations. These methods have also been improved to extend their field of usefulness.

A report has been published on "Diagnosis of mineral deficiencies and excesses by systematic leaf injection and analysis" (K36) and injection methods have been described in detail in three other reports (K 33, 34, 35). The former describes the use of these methods for making a mineral status survey of the fruit trees of the Western Cape Province of South Africa and for a number of practical problems in this country and gives examples of their use by other workers all over the world for solving problems of great economic importance.

Plant Injection.—Beneficial responses have so far been obtained in diagnostic tests to the injection of compounds of nitrogen, phosphorus, potassium, calcium, magnesium, iron, manganese, zinc, boron and copper into the apple, pear, plum, peach, raspberry, rose, potato, tomato, tobacco, broad bean, lupin, soya bean, field pea and oat; in all probability, therefore, the methods are applicable to most plants of economic importance.

During 1940 definite and differential responses to leaf stalk injections of nitrogen, phosphorus, magnesium, zinc, iron, and boron were obtained in Comice pear trees of moderate and poor performance.

Using the same method, deficiencies of potassium, magnesium, iron, zinc and copper were detected in Lane's Prince Albert apple trees which had been clean cultivated for 22 years, and a zinc deficiency only in Cox's Orange Pippin in a plantation in which there was a heavy growth of weeds after 6 years of clean cultivation.

Responses to nitrogen, phosphorus, potassium, magnesium, iron, manganese, zinc and copper were obtained on trees in a plantation which has been kept quite free from weeds for 11 years.

Diagnosis by injection was attempted in two commercial plantations, in one of which responses were obtained to nitrogen and zinc and in the other to nitrogen only. In the latter spectrographic results suggested that manganese would be worth injecting another season under more favourable climatic conditions.

Improvements and simplifications have been made in injection apparatus and methods, both for diagnosis and cure on a commercial scale. Recent experience has proved that these methods reveal the relatively slight degrees of mineral deficiency which are found to be widespread. These appear to be of real economic importance in themselves and their detection at an early stage gives warning of a malnutrition that may become much more serious later.

Plant Analysis.—Further data have been obtained in support of the finding that leaves of the same (or even different but related) species of healthy fruit trees tend to give closely similar spectrograms, even if growing under widely different conditions, and that abnormalities in spectrograms

* See article on p. 46.

may be used to diagnose both mineral deficiencies and unbalanced nutrition. For instance it has been found that excess " lime " inhibits the uptake and upsets the metabolism of elements, such as iron, manganese, zinc and boron. Results suggest that this condition is both prevalent and serious, especially when organic matter is low.

Many diagnoses are possible without actual quantitative analyses but percentage figures have obvious advantages. The flame method of spectrography has been developed to increase its sensitivity and accuracy and to remove as far as possible personal error. A great improvement was effected by replacing the " blow-through " oxy-coal-gas jet by a standard high pressure oxy-acetylene " mixed " jet and by using an oxy-hydrogen high pressure mixed jet. The gas flows have been standardized manometrically. The Ramage manual paper rolling method has been replaced by a standardized folding method. An automatic feed has been perfected. A method under investigation in which the plant material is incorporated in a solid rod of specially purified ammonium chloride may replace the paper folding method for some purposes.

The methods in their present state give reliable figures for lithium, sodium, potassium, rubidium, cæsium, silver, copper and probably manganese. Such analyses are made possible by the use of a photometer. The quantitative side of this work has recently been undertaken.

Because of the effect of aluminium, iron, phosphorus, and silicon on the intensity of the lines of magnesium, calcium, etc., the methods in their present form do not give reliable values for the latter group of elements. Work has been started to make this possible.

Little progress has been possible on the arc-spark method which will be necessary for elements such as zinc, boron, titanium, vanadium, aluminium, nickel, cobalt, phosphorus, etc., and probably silicon ; but this should be possible late in 1941.

Publications during the Year

The Study of Mineral Deficiencies and Excesses by Spectrochemical Methods. S. G. Thompson. Rep. E. Malling Res. Sta. for 1939 (1940), 86-7. (K34.)

Diagnosis of Mineral Deficiencies and Excesses by Systematic Leaf Injection and Analysis. W. A. Roach. Rep. E. Malling Res. Sta. for 1939 (1940), 51-8. (K35.)

Injection for the diagnosis of mineral deficiencies in the Tomato, the Potato, and the Broad Bean. H. Hill and W. A. Roach. Ann. Bot. Lond., 1940, **4**, 505-22. (K36.)

A study was made of the distribution resulting from the injection of an aqueous solution of acid fuchsin into (*a*) an interveinal area of a leaf blade, (*b*) the leaf-tip, and (*c*) the leaf-stalk of the tomato, the potato, and the broad bean. The plants were grown in sand culture deficient in one or more of the elements : nitrogen, phosphorus, potassium, calcium, magnesium, and boron, and were injected with solutions containing the deficient element ; they responded to all the elements injected. The regions of the plants which responded to the nutrient injections were similar to those coloured by the dyes, and the response was local or general according to the injection method used. The distribution of the injected liquids could be explained by the arrangement of the vascular system of the plants. The methods described, (*a*) enable diagnosis of deficiencies to be made in 7-21 days, and (*b*) provide means of rapidly, and without injury, making good any deficiency to which the plant has been subjected.

V. PLANT PATHOLOGY, MYCOLOGY AND BACTERIOLOGY

By R. V. HARRIS and H. WORMALD

A.—Diseases of Tree Fruits.—*Crown Gall.*—Further experiments with strains of the Crown Gall organism from various hosts (including species of Rubus) have confirmed previous observations which suggested that there are biologic strains of *Bacterium tumefaciens* which differ in their ability to infect certain host plants and in their cultural characters.

Brown Rot.—A paper has been published (C158) showing that the Brown Rot fungi, *Monilia fructigena* and *Monilia cinerea* occur on hosts other than the common fruit trees cultivated in this country ; the results indicate that certain ornamental shrubs may serve as sources of infection from which fruit trees may become infected.

Bacteriosis of Plum and Cherry Trees.—Very few further cankers were recorded during 1940 on the plot of Victoria plum trees worked on stems of other varieties, and the results to date show that bacterial canker of plum trees can be satisfactorily controlled by the use of such trees with resistant stems. Purple Pershore and Myrobolan B have so far provided the most successful stems.

Cankers formed on a similar set of plum trees artificially inoculated with *Pseudomonas morsprunorum* in autumn 1939 were measured in 1940. The results, in the main, supported those already obtained proving that stems of Pershore, Denniston's Gage and Victoria were very highly susceptible; stems of President, Utility, Warwickshire Drooper and Purple Egg were intermediate, and stems of Myrobolan B rarely developed cankers at all.

Experiments in the control of bacteriosis by spraying are reported under Section VII (Insecticides and Fungicides).

Bacterial Blossom Blight of Pear Trees.—Inoculation experiments carried out in the spring of 1940 with two organisms isolated from wilted pear blossoms showed that both were able to infect the inflorescences of pear trees and produce Blossom Blight. The two organisms are being studied with a view to determining measures for controlling the diseases. (See Section III, p. 58.)

Apple Scab in Storage.—In March 1940 observations were made on apples taken from a gas store. Many of the apples were seriously disfigured by Storage Scab. This form of Apple Scab had previously been found on apples from ordinary cold storage and the more recent observations showed that it may occur in gas storage also. Measures for its control have been outlined. (C163.)

Angular Leaf Spot of Apple Trees.—The symptoms of Angular Leaf Spot and the fungi found on the spots have been described. (C160.) During 1940 similar symptoms were seen to be associated with infestations by a frog-hopper and it was concluded that the fungi were merely saprophytes on the spots caused primarily by the insect.

B.—Diseases of Soft Fruit.—*Cane Spot of Loganberry and Phenomenal Berry (Elsinoë veneta).*—Preliminary observations and experiments up to the end of 1939 have been published. (C162.) These showed that the disease can be effectively controlled by a combination of spraying and a modified system of training the cane. (See Section IV, p. 89.)

Virus diseases of Cultivated Rubi.—Raspberry Mosaic has now been shown to include two disease groups of distinct virus origin which differ widely in their operation on commercial varieties and are provisionally distinguished as Mosaic I and Mosaic 2. An account of the experiments upon which this conclusion is based and of the distinguishing features of these diseases has been published. (C155.) (For Summary see Ann. Rep. for 1939, p. 30.)

Experiments in 1940 mainly concerned the development of methods for the rapid assessment of the reaction of named and new seedling varieties to each of these mosaic diseases. The improved method of artificial transmission by "cane inarching" was successfully used in these tests. Results confirmed the widespread infection of samples of *Lloyd George* cane hitherto regarded as mosaic-free, with a severe form of Mosaic 2. The recently introduced variety *Preussen*, was also shown to approximate closely to the symptomless-carrier reaction of Lloyd George although leaf-symptoms are occasionally expressed. *Burnet Holm* and *Pyne's Royal* were shown to be completely permeated with virus with indistinct and intermittent symptom-expression, and, in contrast, cane of a clone of *Norfolk Giant* selected for freedom from virus symptoms proved on testing to be entirely free from virus. Test transmissions were set up with eight selected seedling varieties of promise with the object of rapidly determining their reaction to mosaic diseases prior to their introduction. With such information appropriate control measures can be applied at the outset to ensure the prolonged survival of important new varieties.

Virus Diseases of Strawberry.—A review of research on this disease from 1923 to 1939 inclusive was published in 1940 (C161). Experiments were continued on the comparative performance of West Ireland strains of Royal Sovereign previously found to be entirely free from virus. These have so far given promising results.

An experiment completed during 1940 showed that the warm water treatment of Royal Sovereign runners for the elimination of Tarsonemid Mite does not modify the intensity of reaction to the Yellow-edge virus.

Some 30 promising strains of a selected range of varieties, of both the "carrier" and "non-carrier" types were collected. Tests of each of these strains, including stolon inarching to *Fragaria vesca* indicator plants, were set up with the object of discovering virus-free plants.

Runners of five varieties from plants shown by 1938 and 1939 tests to be either entirely virus-free or free from Yellow-edge virus, were transferred to a specially constructed gauze aphis-proof chamber for initial runner propagation prior to field trial.

C.—Diseases of Hops.—See under VIII. Hops.

D.—Miscellaneous Investigations.—*Spotting of Broccoli from Cold Storage.*—Cold storage chambers when not in use for fruit may be used for the cold storage of certain vegetables, particularly cauliflower and broccoli. In collaboration with the Ditton Laboratories a spotting of broccoli has been investigated. The spotting appears within a few days after the broccoli are taken from gas storage and renders them unfit for sale. A fungus, a species of Alternaria, has been isolated from such spots, and its relation to conditions under which the broccoli are stored is being investigated.

Host Plants of the Brown Rot Fungi in Britain. H. Wormald. Trans. Brit. mycol. Soc., 1940, **24**, 20-28. (C158.)

Notes on Plant Diseases in 1939. H. Wormald and R. V. Harris. Rep. E. Malling Res. Sta. for 1939 (1940), 58-62. (C159.)

The Angular Leaf Spot of Apple Trees. H. Wormald. Rep. E. Malling Res. Sta. for 1939 (1940), 63-66. (C160.)

Review of Research on Strawberry Virus Diseases, 1932-1939. R. V. Harris and M. E. King. Rep. E. Malling Res. Sta. for 1939 (1940), 66-68. (C161.)

A Review of Research on Cane Spot of Loganberry and Phenomenal Berry. R. V. Harris, A. B. Beakbane and M. H. Moore. Rep. E. Malling Res. Sta. for 1939 (1940), 68-9. (C162.)

Storage Scab of Apples. H. Wormald. Gdnrs' Chron., 1940, **107**, 257. (C163.)

Severe Storage Scab was found in February, 1940, on Cox's Orange Pippin apples when they were taken from gas-storage. Such conditions are therefore favourable for the development of this form of scab, which had previously been found on apples in ordinary cold storage. Control measures recommended are (1) the prevention of Apple Scab in the orchard by routine spraying with Bordeaux mixture or lime-sulphur, which may be followed, if necessary, by colloidal sulphur or sulphur dust; (2) avoiding storing fruits when they have any surface moisture.

A Functional disorder of cultivated varieties of Rubus. R. V. Harris. Trans. Brit. myc. Soc., 1940, **24**, 265. (C164.)

A summary of a paper read to a meeting of the British Mycological Society. It briefly recounts the recent experiments on a Die-Back of Lloyd George raspberry canes at East Malling. The results of the experiments suggest that the Die-Back is mainly due to insufficiently low winter temperatures that fail to break the winter rest period.

The Strawberry Yellow-edge disease in relation to weather conditions. M. E. King and R. V. Harris. Trans. Brit. myc. Soc., 1940, **24**, 265-6. (C165.)

A summary of a paper read to a meeting of the British Mycological Society. It describes the experiments on the effect of weather conditions on the prominence of the diagnostic symptoms of Strawberry Yellow-edge. The experiments showed that the optimum symptom-expression occurred about a week after the temperature became sufficiently high and there was adequate soil-moisture. Roguing is most efficient when carried out during this period.

VI. ENTOMOLOGY

By A. M. MASSEE and R. M. GREENSLADE

Apple Blossom Weevil.—Three control methods have been investigated:

(*a*) Repellants. Fourteen substances have been tested in the laboratory, and four of these were selected for a field trial. Of these one slightly reduced the infestation by keeping the weevils away from the flower buds during the egg-laying season.

(*b*) Atomized pyrethrum spraying. This method reduced the infestation very slightly, but owing to unsuitable weather conditions could not be applied until most of the eggs were already laid.

(*c*) The use of trap bands treated with substances which might be attractive to the weevils, and the use of bands made of moss and sacking. None of the substances used was effective in increasing the catch of weevils. Moss was not successful. Sacking, the original recommendation for trapping, was twice as effective as corrugated cardboard.

Woolly Aphis.—Trials of mineral oil sprays with nicotine for summer use have been carried out whenever the insect was sufficiently numerous. Previous observations that mineral oils were no improvement on nicotine and soft soap were confirmed. Care in spraying is of more importance than the nature of the spray fluid.

Apple and Pear Aphides.—A study of the aphides on apple and pear was begun, particular attention being given to such differences of life-history as may affect control measures. At present the pear species are being studied in collaboration with the Insecticides and Fungicides Section.

The Insect and Allied Fauna of Rubus.—*Insect Transmission of Raspberry Mosaic.*—Experiments are continuing in an effort to find the vector of raspberry mosaic. Direct inoculation experiments have been made using *Aphis idaei* Van der Goot, and *Amphorophora rubi* (Kalt). The variety Baumforth B is being used in place of Lloyd George.

Dwarf Disease of Rubus.—Direct inoculation experiments have been started with *Macrosiphum rubiellum* Theob. and *Aphis idaei* Van der Goot on several varieties of cultivated Rubus.

Strawberry Investigations.—*Insect Transmission of Crinkle.*—A series of tests have been made to see whether the Rose Leaf Hopper (*Typhlocyba rosae* L.)—the common strawberry species—is a vector of strawberry Crinkle virus. Negative results have been obtained.

Aphis survey.—The hard winter of 1939-40 almost exterminated *Capitophorus fragariae* Theob.; in March one aphis was found after examining 500 plants. This prevented further work on population sampling, but regular surveys of the increase and spread of the aphis were made throughout 1940. By October the population was almost normal.

Strawberry Aphis Control.—Investigations on the control of strawberry aphis with vaporized nicotine are being continued.

A Study of the Vectors of "Reversion" of Black Currants.—Direct inoculation experiments have been made with the common Green Capsid Bug (*Lygus pabulinus* L.). Promising results had been obtained by the autumn of 1940 and the work is being continued.

Black Currant Leaf Midge.—The life history of this Midge (*Dasyneura tetensi* Rübs.) has been worked out in the field. Four generations of midges were observed in 1940, the first in May and the last in August. There is evidence that some of the adults of the last generation do not emerge until the following spring. The infestation of bushes in the field was found to be heaviest in places sheltered from the wind, and differences in susceptibility of different varieties of black currant were discovered. Preliminary experiments were made on the control of this pest.

Publications during the Year

A Study of the Variation of Size within two species of Aphides. G. H. L. Dicker and S. C. Pearce. Bull. ento. Res., 1940, **31**, 45-56. (D142.)

The Biology of the Rubus Aphides. G. H. L. Dicker. J. Pomol., 1940, **18**, 1-33. (D144.)

Notes on some Interesting Insects Observed in 1939. A. M. Massee. Rep. E. Malling Res. Sta. for 1939 (1940), 70-3. (D147.)

Dipping of Strawberry Runners before Planting. A. M. Massee and R. M. Greenslade. Rep. E. Malling Res. Sta. for 1939 (1940), 73-4. (D148.)

Reoccurrence of Eurydema dominulus Scop. (Hem. Pentatomidae) in its old locality in Mid Kent. A. M. Massee. Ent. mon. Mag., 1940, **76**, 256. (D149.)

The Occurrence of Typhlocyba froggatti Baker (Hemipt.) in Kent. A. M. Massee. Ent. mon. Mag., 1940, **76**, 257. (D150.)

The occurrence of the leaf hopper *Typhlocyba froggatti* Baker is recorded on apple, pear, plum and cherry in the Maidstone district of Kent.

Twig-Cutting Weevil. A. M. Massee. Gdnrs' Chron., 1940, **107**, 325-6. (D152.)

Notes are given concerning the Twig-cutting Weevil (*Rhynchites cæruleus* D.G.) which is a minor pest of apple.

Ceratitis capitata Wied. (Dipt., Trypetidae) in Middlesex. A. M. Massee. Ent. mon. Mag., 1940, **76**, 112. (D153.)

Two specimens of the Mediterranean Fruit Fly, *Ceratitis capitata* Wied. were bred in the laboratory from apples sent in from a private garden in Middlesex. Other larvae were present but did not mature.

Gnorimus nobilis L. (Col. Scarabæidae in Kent. A. M. Massee. Ent. mon. Mag., 1940, **76**, 107. (D154.)

A number of larvae of *Gnorimus nobilis* L. were found feeding in the trunk of a decayed Keswick Codling Apple tree at East Malling.

Some Important Pests of Fruit. A. M. Massee. Farmers' Weekly, 1940, **12**, 33. (D155.)

On Rubus Aphides and Leafhoppers as possible Vectors of Raspberry Mosaic. G. H. L. Dicker. J. Pomol., 1940, **18**, 275-86. (D156.)

No species of insect has yet conclusively been proved to transmit raspberry Mosaic in Great Britain. The eight species of aphides and the leaf-hoppers known to occur on Rubus in this country are discussed as possible vectors in the light of observations made at East Malling during the last few years.

VII. INSECTICIDES AND FUNGICIDES

Laboratory Investigations.—Ovicides.—Further work on the ovicidal properties of tar and petroleum distillates showed that distillation range, viscosity, and specific gravity do not fully account for observed differences in the toxicity of different types of oil to Winter Moth eggs. Of a mineral oil, a high-temperature horizontal-retort tar oil, and a low-temperature tar oil, each having a distillation range of 320-380° C., the mineral oil was about three times as toxic as either of the tar oils, which were about equal in toxicity. Further work in collaboration with the Department of

Entomology, Imperial College of Science, showed that the oxygen uptake of Vapourer Moth eggs treated with fatal doses of nicotine was about normal and that the embryos (like those of *Aphis pomi*) developed, even though they failed to hatch. After treatment with a petroleum emulsion, however, the oxygen uptake was depressed or inhibited and the embryos failed to develop.

Fungicides.—More than forty organic compounds, mainly phenols or thio derivatives, were tested for fungicidal properties against the Apple Scab fungus. The results indicate possible relationships between constitution and toxicity, and are now being used as a basis for systematic attempts to synthesize new organic fungicides.

Bactericides.—A survey of eighteen commoner metals, all tested as nitrates, showed that mercury, silver, chromium, and copper, in that order, are the most toxic to the Plum Bacterial Canker organism. Bordeaux mixture, however, was no more toxic than a suspension of calcium hydroxide of similar alkalinity. It was found that the degree of toxicity of a large number of alkalis and acids depends upon the hydrogen ion concentration of the solutions rather than upon a specific toxicity of the substances. A trial designed to examine this phenomenon in the field has been started.

Field Investigations.—Insecticide Trials.—A field trial on apples of dual-purpose winter washes confirmed earlier conclusions that 0·05% of 3 : 5 dinitro-*o*-cresol, in a sulphite lye emulsion of 5% winter petroleum oil, is a sufficiently high concentration to control Aphis and Sucker. Lethane 410 (75% β-butoxy-β′-thiocyanodiethyl ether), in a similar oil emulsion, was less effective, even at 0·1%.

Fungicide Trials.—*I. Small Scale* (1939).—In comparison with several new fungicides on four commercial Scab-susceptible apple varieties, lime-sulphur, specially dilute, proved safe and gave better control of Scab than any of the others except a new "wettable" sulphur preparation which, however, moderately russeted the fruit. Lime-sulphur gave the best control of Red Spider. A commercial preparation of tetramethylthiuram disulphide was safe, gave moderate Scab control, and was unsatisfactory against Red Spider. A zinc-lime "Bordeaux" behaved similarly.

(1940). Specially dilute (1%) lime-sulphur was compared with mixtures of 0·5% lime-sulphur with (i) a colloidal sulphur preparation and (ii) "wettable" sulphur. Polysulphide sulphur was supplemented by an approximately equal amount of elementary sulphur. All sprays gave very good control. In general, the mixtures were not less effective than lime-sulphur against Scab and all were safe and worth further attention. A mixture of "full strength" colloidal sulphur with "half strength" colloidal copper was very fungicidal but not safe, the damage being due to the presence of the colloidal copper.

II. Large Scale (1939).—Lime-sulphur and the colloidal sulphur each gave very good Apple Scab control on Cox's Orange Pippin and Worcester Pearmain when used twice pre- and three times post-blossom, or when either spray used twice pre-blossom was followed three times post-blossom by the other. Colloidal sulphur was safer than lime-sulphur, but not as effective against Red Spider.

(1940). Lime-sulphur and the "wettable" sulphur each gave very good Apple Scab control; colloidal sulphur was rather less effective. With the last two, each a preparation of elementary sulphur, toxicity was approximately in direct proportion to sulphur content of the diluted sprays. Polysulphide sulphur was, fungicidally, acaricidally, and phytocidally, the more potent though cheaper unit. No spray damage accrued from either spray based on elementary sulphur, but lime-sulphur, as often, caused reduction in leaf size. "Wettable" sulphur maintained the distinct promise shown in 1939.

Spray Damage Investigations.—Experimental evidence that much winter petroleum damage is due at least as much to spraying in windy weather as to spraying during an unsafe period, was secured in a field trial on Victoria plums. The rate of application was more important than the choice of date, two sprayings of 5% oil giving consistently more damage than one. The physiological condition of the buds in relation to this spray damage is being investigated.

Summer petroleum oil, emulsified with sulphite lye, caused but little damage on Cox's Orange Pippin and Worcester Pearmain when used at petal-fall, and none when used in early July. With lime-sulphur, however, it caused severe leaf- and fruit-drop when applied at petal-fall, but no damage in early July.

Experiments have been started on the effect of adding minute quantities of synthetic growth substances to such sprays as lime-sulphur, summer oil emulsions and mixtures of the two. α-Naphthalene-acetic acid and oil gave significantly less fruit drop than oil alone, though, in 1940, the oil itself did not cause excessive drop.

On apples a calcium arsenate preparation caused more damage than a lead arsenate preparation whether used alone, or mixed with lime-sulphur or with a "wettable" sulphur. Serious damage followed each post-blossom spray incorporating calcium arsenate, and a late June application produced almost complete defoliation of Cox's Orange Pippin and Lord Derby. The damage, although apparently arsenical, was not due to soluble arsenic in the wash, but appeared to arise from some subsequent reaction of the deposit.

Various sulphur sprays known to be fungicidal against Apple Scab showed little deleterious effect on the setting of apple blossoms when applied in full bloom in 1939 and 1940.

Biology and Control of Specific Pests and Diseases.—*Red Spider.*—Abundant evidence was secured that the adult females migrate readily with the aid of air currents (Q23). This throws much light on difficulties that have been experienced both in the control of this pest, and in the interpretation of experimental results.

Apple Capsid.—Field trial showed that a petroleum emulsion was significantly less effective applied on 29th February than on either 20th March or 2nd April, and that the concentration of oil can be reduced from 6% to 5% for late spraying.

Apple and Pear Aphides. See Entomology.

Brown Rot in Morello Cherries.—Very good control was given by one winter application of soap-emulsified 3% neutral tar oil with or without tar phenols, and by a dinitrocresol-petroleum emulsion. Infection on control trees was extremely heavy.

Bacteriosis in Plums.—Leaf-spot infections on Victoria were very slight and the spraying trial yielded no evidence as to control. Two summer applications of Bordeaux mixture with cotton-seed oil, however, gave good control of *Puccinia Pruni-spinosae,* but the later of these, applied at the end of June, left an unsightly deposit on the picked fruit and would thus be unsuitable for use on cropping trees. Leaf-fall in autumn was delayed by these sprays.

Apple Scab.—Infection was severe on differentially manured, unsprayed trees growing in unfavourable soil conditions, but the crop was light and irregular and the results inconclusive. A similar manurial trial has been begun on similar trees growing in favourable soil conditions. Both sets of trees will eventually be used in addition for observations on nutritional influence on spray damage.

Bud Rot.—Inoculations of Grenadier apple buds with *Fusarium lateritium* in February failed to cause infection, though many Grenadier buds remained dormant on trees in a spraying trial of winter petroleum oil. No relationship was established between the spraying and the dead buds, many of which showed *Fusarium* coremia on incubation. The influence of an autumn application of Bordeaux mixture on the incidence of Bud Rot is being tested in the field.

Apple Branch-Blister Disease.—Much more blister developed on potted-up Cox trees kept under controlled drought conditions than on similar, well-watered, trees. Application of potash had no marked effect on the incidence of blister under these conditions.

Loganberry Cane Spot.—Control measures, by spraying and appropriate training of canes, are being worked out in collaboration with the Mycology and Pomology Sections (*q.v.*). A review of progress made has recently been published. (C162.) Infection was reduced in 1940 by Bordeaux mixture applied at the end of August 1939 (post-cropping) or in May 1940 (pre-blossom). No improvement in control was obtained this year where an application of colloidal copper in June (beetle stage) was added to that of Bordeaux in May. (See also Section IV of this Report, p. 89.)

Apple Canker.—The effect of autumn, spring, and autumn and spring applications of Bordeaux mixture or of a colloidal copper preparation on the control of this disease is being investigated. In collaboration with the Pomology Section, observations are being made on the influence of cover crops on the resistance of trees to canker.

H.B.S.M., M.H.M., H.S. and W.S.

Publications during the Year

A Brief Review of Research Work at East Malling on the Control of Apple Scab. M. H. Moore. Rep. E. Malling Res. Sta. for 1939 (1940), 74-5. (Q20.)

Symposium on : Efficiency with economy in the control of plant diseases and pests. II. Protective Fungicides. M. H. Moore. Summary in Ann. appl. Biol., 1940, **27,** 436-7. (Q21.)

Apple Scab is instanced as a good example of the large class of diseases that are controlled by protective spraying. Four points are emphasized as of great importance: (1) correct timing of spray-applications, (2) strengths of sprays, (3) methods of application, (4) adequate and balanced nutrition.

Symposium on : Plant diseases and the Weather. VI. The effect of weather on some diseases of apple and Morello cherry. M. H. Moore. Summary in Trans. Brit. mycol. Soc., 1940, **24,** 266. (Q22.)

Some effects of weather conditions, particularly rainfall, in relation to the incidence of Scab (*Venturia inæqualis*) and Branch-Blister disease (functional) in apples, and of Brown Rot (*Sclerotinia laxa*) in Morello cherries, are briefly summarized.

Migration of the Red Spider. W. Steer. Gdnrs' Chron., 1940, **108,** 28-9. (Q23.)

A description of the means by which Red Spiders travel from tree to tree.

VIII. HOPS

A.—Varieties and Cultivation Trials.

By F. H. BEARD

Commercial Varieties. -Progress has been made with the clonal propagation of disease-free non-carrier strains of Golding and Fuggle Hop, which will subsequently be tested for yield.

New Varieties.—The crop from about 120 varieties was dried separately in order that the yield per acre and the number of bushels of green hops required to yield a cwt. of dried hops could be estimated. Samples of dried hops of 15 varieties were saved for subsequent resin analysis. The crops from 17 varieties were pressed separately in part pockets for use in brewing trials.

The analysis of the 1939 crop showed that GG60 was the richest early variety with a P.V. of 9·38. This variety is very early in season and rather a slight cropper.

In the mid-season class the two richest varieties were BB28 (13·74) and HH44 (13·51). These varieties show promise commercially and are being propagated on a larger scale.

Among the late varieties OB53 (Nonsuch Hop) came first with a P.V.15·21. It is thought that this variety is the richest recorded variety in the world. However, it gives very small crops so that its commercial value is doubtful. Bullion Hop (Q43) was second with 14·89 P.V. and Brewer's Gold (C9a) was third with 12·94 P.V. These two varieties are now being planted by brewers in this country and by growers in Canada and U.S.A. Five of the new varieties (OB53, Q43, C9a, BB28, HH44) proved richer than the best American growths.

The analysis of samples of Brewer's Gold (C9a) and Bullion Hop (Q43) grown in this country and overseas showed that the home-grown growths are equal to those grown in warmer climates.

The above results were published by Professor E. S. Salmon of the South-Eastern Agricultural College, Wye. (B36.)

Cultural Trials.—The results of these trials to date have been published. (B35.)

Distance between the hills has had a marked influence on the yield both per hill and per acre. The effect of the number of bines per string has been much less. Operations such as cutting and pulling have so far had little if any effect on the cropping.

"Stopping" of the bines at the lacing string has prevented the formation of dense "heads" (undesirable when hops are picked by machine) but has also reduced the yield.

Manurial Trials.—Differences in foliage colour were shown by the high and the low nitrogen plots of OI47 during the summer. No crop records were obtained as owing to drought conditions the cones failed to develop.

Root Studies.—Two observation root trenches have been installed and planted with strap cuts of Fuggle and Brewer's Gold. Weekly records of root growth and daily records of soil temperature and moisture were obtained. Root growth was very rapid during June and early July. No growth (other than thickening of existing roots) was recorded after the end of August. Drought conditions obtained after this date. There was a difference between the root systems of the two varieties. The amount of both shoot and root growth was great and illustrated the amount of growth that could be expected from cuttings when given ample room.

B.—Diseases of Hops.

By W. G. KEYWORTH and D. L. G. DAVIES

Verticillium Wilt.—The work in 1938 and 1939 was published (C154) and the investigation was continued in 1940.

The disease spreads on a farm by the transport of infected plant material by the customary cultivation operations and the spores of the fungus can probably be carried to nearby farms by wind. Outbreaks unchecked at an early stage rapidly become uncontrollable.

In a small preliminary trial of soil disinfection 2% formalin reduced the amount of disease from 47% to 6%, but this reduction was not maintained in subsequent trials on a commercial scale which demonstrated practical difficulties in obtaining adequate soil penetration.

All commercial varieties have been shown to be equally susceptible to the disease, and testing of new seedling varieties has been started.

Methods of cultural hygiene have been devised. These at present provide the principal means

of control, and their prompt application to certain small outbreaks has resulted in the apparent eradication of the disease.

Nettlehead, Mosaic and other Diseases.—An account of farm surveys made in 1939 was published (C157) and showed that Nettlehead was the most widespread of possible virus diseases in the Fuggle variety, few farms being free from it. Mosaic Disease was severe in Golding varieties on many farms. The symptoms of Nettlehead and other diseases of hops were briefly described (C156).

Research in 1940 was mainly concentrated on experiments in artificial transmission to verify the virus origin of Nettlehead and to determine any causal relationship of this disease and mosaic. A technique of graft-inarching was successfully elaborated by means of which many healthy and diseased plants were organically united. Nettlehead symptom expression however was too poor in 1940 to enable verification of virus transmission and the plants will be transferred to open ground for further observation. By inarching experiments the Fuggle hop was proved to be a symptomless-carrier of Mosaic disease.

As a preliminary to the establishment of disease-free Fuggle clones cuttings collected from seven apparently Nettlehead-free gardens were grown in isolation prior to their direct testing for disease.

Observations have shown that Nettlehead incidence may be related to the manurial content of the soil. Two experiments have been laid down on commercial farms to investigate this subject.

C.—Entomological Investigations.

By A. M. MASSEE

Insect Fauna of the Hop.—A study of the insects associated with the cultivated hop indicates that the fauna varies considerably from district to district. For example, in the Maidstone area aphides and leaf hoppers are very common, whilst in the Paddock Wood district a species of thrips and the hop strig maggot are widespread. The Hop-Damson Aphis is abundant everywhere.

(*a*) **Insect Transmission of Nettlehead.**—Experiments are in progress to discover the insect vectors of Nettlehead. Direct inoculations have been made with a species of leaf hopper, under insect-proof conditions.

(*b*) **Mosaic.**—Direct inoculation experiments have been made with the Hop Frog Hopper, which is a common insect in many hop gardens. The results of these experiments will not be available until 1941.

The Hop Strig Maggot.—The life-cycle of the Hop Strig Maggot has been worked out under field conditions. Among points of interest it has been confirmed that there is only one generation in a year. Control measures are also being investigated.

Hop Red Spider.—The phytocidal tests initiated in 1939 have been repeated on two varieties of hop. The results, confirming those of 1939, demonstrate that it is quite safe to apply a 1% lime-sulphur spray to the young hop bine in May and June, without causing damage to the plant.

Publications during the Year

The Effect of Various Cultural Treatments on the Cropping of Hops. F. H. Beard. Rep. E. Malling Res. Sta. for 1939 (1940), 75-8. (B35.)

Twenty-third Report of the Trial of New Varieties of Hops. 1939. E. S. Salmon. August 1940. (B36.)

Of the 224 varieties (New and Commercial) tested, 11 New Varieties cropped at the rate of over 30 cwt. to the acre, 37 at 25 cwt. or over to the acre and 74 at 20 cwt. or over. The number of bushels (Imperial) of green hops required to the cwt. of dried hops varied from 77 to 160. Thirteen New Varieties proved on analysis to be richer in preservative qualities than the richest old variety (Mathon). Five of the New Varieties, viz. OB53 ("Nonsuch Hop"), Q43 ("Bullion Hop"), C9*a* ("Brewer's Gold"), BB28 and HH44 were richer in preservative qualities than the richest sample of American hops obtainable—"Bullion Hop" by 2·99% and "Brewer's Gold" by 1·04%. A Table is given of the preservative values of growths of "Brewer's Gold" and of "Bullion Hop" produced abroad.

Information is given on the valuation of "Brewer's Gold" by the Hops Marketing Board, and also on certain points concerning the New Varieties presented, by request, to a Committee of the Board. Notes are given on recent brewing trials with certain of the New Varieties. The incidence of Mosaic Disease, Downy Mildew and Verticillium Wilt is recorded.

Hop Pests. A. M. Massee. Fmrs' Weekly, 1940, **13**, 29. (D151.)

IX. TECHNICAL SECTION

The Technical Section has continued to maintain contact with growers by means of correspondence, and by the editing of a "Seen on Survey" column in the *Kent Farmer's Union Journal*. At the same time the Section has continued to keep an eye on trials such as the training of dwarf pyramids and the summer pruning of cordon pears. The Section has also carried out the administrative and clerical work in connection with the fruit survey which twelve members of the staff undertook in the autumn at the request of the K.W.A.E.C., under Mr. W. G. Kent's general supervision. The year saw the publication of 15 popular bulletins or leaflets.

Publications during the Year

A Chance for English Walnuts. N. B. Bagenal. Fruitgrower, 1940, **90**, 274. (E166.)

A brief account of the methods of growing, harvesting and marketing of walnuts in the Grenoble area and a plan for increased attention to English walnuts in order to fill a gap of some 50,000 cwts., formerly imported annually from France.

Plum Growing in the Light of Recent Research. N. B. Bagenal. Rep. E. Malling Res. Sta. for 1939 (1940), 79-84. (E170.)

Section III

RESEARCH REPORTS

POMOLOGY

PRELIMINARY SELECTION OF APPLE ROOTSTOCKS IMMUNE FROM WOOLLY APHIS BASED ON CERTAIN ANATOMICAL DIFFERENCES IN ROOT STRUCTURE

By A. B. BEAKBANE, E. C. THOMPSON and H. M. TYDEMAN

THE fruit-tree rootstocks at present in use have been selected over many years because they could be propagated readily, proved healthy in the nursery, were compatible with most scion varieties and produced vigorous nursery trees with apparently balanced root systems. The rootstocks which ultimately survived these important yet rudimentary trials have been proved by more modern and detailed investigation to possess a comparatively wide range of influence over the cropping, health and longevity of the scion worked upon them. This result must be attributed to good fortune rather than good judgment. A close study has not revealed any correlation between the vigour, cropping capacity and other qualities of the rootstock itself and those of the scion variety with which it is combined, and the selection of rootstocks having any particular influence over the scion variety has been very largely a matter of trial and error. A deciduous fruit-tree does not show its full potentialities for a very long period, and an apple tree on a dwarfing rootstock, when properly treated, shows no sign of having passed its prime at twenty years, so that the process of testing these rootstocks must be a protracted one.

Now that so much more is known about the part which the rootstock plays in influencing the growth, cropping and health of the scion (Hatton, 1927, 1930, 1935, 1938), the plant breeders have set to work to combine in a series of rootstocks both the characters required by the nurseryman and the influences upon the scion variety desired by the fruitgrower. As a result of the combined efforts of this Station and the John Innes Horticultural Institution since 1921, something like eight hundred rootstocks, after severe test, have been found to be immune or highly resistant to attack by Woolly Aphis. Full details of the families which have been raised and the genetical and entomological aspects of the work may be found elsewhere (Crane and others, 1936, 1937). It is sufficient here to say that by crossing the Malling series of apple rootstocks with the immune Northern Spy and other immune varieties a deliberate attempt was made to produce a new series of apple rootstocks which possessed a high degree of resistance to Woolly Aphis attack in addition to the desired influence upon the vigour, cropping and other characteristics of the scion.

These immune seedlings have now undergone the first essential test to determine which, if any, are fit to be put into commercial circulation. They have all been subjected to "stooling" or "layering" methods of vegetative propagation to determine whether they could be reproduced readily and healthily in quantity. The differences exhibited by the individual seedlings in the number of shoots formed by the stools or layers and in the readiness with which they formed adventitious roots when earthed up have already been described (Tydeman, 1941*a*). From the nurseryman's point of view about 15 per cent. of these rootstocks proved of sufficient merit to justify their adoption into commercial use. At the same time nothing was known of their potential influence on the vigour or cropping of the scion nor of their compatibility with the numerous varieties commonly grown. Four rootstocks, raised quite early in these experiments and now known as the Merton Immunes, had been under test, budded with Lane's Prince Albert since 1930. Early indications suggest that they fall into a slightly more vigorous class than that of their parents Malling No. II and Northern Spy (Tydeman, 1935, 1941*b*). In a preliminary attempt to obtain data upon the compatibility and other characteristics of a larger number of these rootstocks the shoots of about 250, while still growing upon the stools, were grafted with Lane's Prince Albert. The grafts took very well, but when the trees were removed at the end of their first season for planting out they were found to be very variable, and a number have since died. Little reliance could be placed upon data of vigour and cropping from such trees until the initial differences have had time to work themselves out.

It seemed fairly clear as the work proceeded that to test even a fraction of the large number of root stocks available, upon a sufficiently extensive scale to make reliable deductions possible as to their influence upon the scion over the long period necessary, would require far more land than was available for the purpose. Before it was possible to proceed to this, the next logical step in this work, it became very desirable to find some rapid method by which the rootstocks could be approximately grouped into classes based on their influence on the vigour and fruitfulness of the scion in much the same way as Hatton was able to classify the Malling series as a result of many years study of the growing trees. If this could be done, representatives of the whole range of potential rootstock influence could be included among the relatively few individuals which it would be possible to carry forward into an extended field trial.

Fortunately, at the time when this question had become urgent, two of the writers (A.B.B. and E.C.T.) were engaged on an intensive study of the anatomical structure of the roots of deciduous

TABLE I.

SHOWING THE FIFTY-FIVE APPLE ROOTSTOCKS FINALLY SELECTED FOR FURTHER TRIAL.

Index No.	Parentage.	Percentage bark in root.	Index No.	Parentage.	Percentage bark in root.
		GROUP A.			
Im 287	Northern Spy × Malling No. XII ..	31·4	Im 280	Northern Spy × Malling No. XII..	34·2
,, 279	Northern Spy × Malling No. XII ..	31·7	,, 304	Northern Spy × Malling No. XII..	35·0
,, 306	Northern Spy × Malling No. XII ..	33·1	,, 238	Northern Spy × Malling No. II. ..	35·7
,, 288	Northern Spy × Malling No. XII ..	33·9			
		GROUP B.			
Im 605	Northern Spy × Winter Majetin ..	37·9	Im 81	Malling No. II × Northern Spy C...	40·9
,, 617	Northern Spy × Winter Majetin ..	38·6	,, 319	Northern Spy × Malling No. I ..	41·0
,, 74	Malling No. II × Northern Spy C. ..	39·3	,, 278	Northern Spy × Malling No. II ..	41·1
,, 307	Northern Spy × Malling No. XII ..	39·1	,, 774	Malling No. II × Northern Spy C.	41·4
,, 208	Northern Spy × Malling No. I ..	39·8	,, 14	Malling No. XV × Northern Spy ..	41·7
,, 524	Northern Spy × Merton No. 793 C.*	40·3	,, 323	Northern Spy × Malling No. I ..	42·0
		GROUP C.			
Im 411	Malling No. II × Northern Spy ..	42·2	Im 259	Northern Spy × Malling No. II ..	44·6
,, 469	Northern Spy × Reinette Zuccamaglio	42·5	,, 10	Northern Spy × Malling No. XV ..	44·7
,, 200	Northern Spy × Malling No. II C. ..	42·8	,, 12	Northern Spy × Malling No. XV ..	44·9
,, 69	Malling No. II × Northern Spy C. ..	43·5	,, 671	Northern Spy × Ben Davis ..	44·9
,, 250	Northern Spy × Malling No. II ..	43·6	,, 270	Northern Spy × Malling No. II ..	45·8
,, 202	Northern Spy × Malling No. II C. ..	44·5	,, 609	Northern Spy × Winter Majetin ..	45·9
		GROUP D.			
Im 7	Northern Spy × Malling No. I C. ..	48·1	Im 249	Northern Spy × Malling No. II ..	50·4
,, 11	Northern Spy × Malling No. XV ..	48·4	,, 106	Malling No. I × Northern Spy C.	50·6
,, 254	Northern Spy × Malling No. II ..	48·5	,, 151	Malling No. II × Northern Spy C...	52·1
,, 265	Northern Spy × Malling No. II ..	48·6	,, 554	Merton No. 793 × Northern Spy C.	52·4
,, 96	Malling No. I × Northern Spy ..	50·0	,, 321	Northern Spy × Malling No. I ..	53·4
,, 332	Northern Spy × Malling No. I ..	50·3	,, 425	Malling No. II × Northern Spy ..	53·7
		GROUP E.			
Im 665	Northern Spy × Ben Davis ..	55·0	Im 90	Northern Spy × Malling No. II C.	56·6
,, 328	Northern Spy × Malling No. I ..	55·2	,, 107	Malling No. I × Northern Spy C	57·1
,, 133	Malling No. I × Northern Spy C. ..	55·2	,, 168	Northern Spy × Malling No. I C.	58·1
,, 161	Northern Spy × Malling No. I C. ..	55·6	,, 134	Malling No. I × Northern Spy ..	58·2
		GROUP F.			
Im 495	Northern Spy × Merton No. 793 C...	60·7	Im 434	Northern Spy × Malling No. II ..	61·0
		GROUP G.			
Im 318	Northern Spy × Malling No. I ..	66·6	Im 549	Merton No. 793 × Northern Spy C.	71·0

* Selected from Malling No. II × Northern Spy.

Those families followed by a C. were raised by Mr M. B. Crane at Merton, the rest by one of the authors (H.M.T.) at East Malling.

fruit-trees and had already succeeded in establishing a correlation between the proportion of bark to wood in the roots of apple rootstocks and the vigour of the worked trees of which they formed a part (Beakbane and Thompson, 1939; Beakbane, 1941). The present problem seemed to provide an excellent opportunity to put these findings to a practical use on an extensive scale.

In February 1941 roots of approximately one quarter to one half inch in diameter were taken from the stooled or layered plants of these rootstocks. The roots were sawn transversely with a fine-toothed saw and a plate, roughly one eighth inch thick, removed and treated with a solution of phloroglucinol followed by concentrated hydrochloric acid which stained the wood red. The pieces of root were examined microscopically. The diameter of the wood and the width of the bark were measured with an eyepiece micrometer and the approximate proportion of wood in the section calculated.

The percentage of bark in the roots of the different seedlings varied from 71 to 31. Seven equal groups were made covering this whole range of difference, and within each group those rootstocks which had shown the greatest promise under the propagation tests were selected. Ultimately, the fifty-five individuals shown in Table I were chosen for the final trial. In comparable roots of the Malling series the percentages of bark in the roots were as follows: Malling No. IX, 66 per cent.; Malling No. II, 54 per cent.; and Malling No. XII, 36 per cent. Roots from six-year-old trees of Lane's Prince Albert growing on these three Malling rootstocks, Northern Spy and the four Merton immunes were examined. The percentage of bark in the roots and the length of new wood made by the trees during the six years are shown in Table II.

TABLE II.

SIX YEARS' TOTAL WOOD GROWTH AND THE PERCENTAGE BARK IN THE ROOTS.

LANE'S PRINCE ALBERT ON DIFFERENT ROOTSTOCKS.

Rootstock.	Six years wood growth. Metres.	Percentage bark in roots.
Malling No. XII	305	30
Merton No. 789	255	42
,, 793	243	43
,, 779	243	39
,, 778	203	41
Northern Spy	169	47
Malling No. II	163	54
Malling No. IX	119	64

The correlation between vigour as expressed by wood growth and root structure was very close in this series. Illustrations of the internal root structure of a dwarfing and vigorous rootstock are shown in Figs. 1 and 2.

It would seem from the root structure, therefore, that the rootstocks in Group F, Table I, should be similar to the dwarfing Malling No. IX, those in Group D only slightly more vigorous than the "semi-dwarfing" Malling No. II, while the rootstocks in Group A should prove more vigorous than the vigorous Malling No. XII.

All the eight hundred immune seedlings with the exception of these fifty-five have been, at least temporarily, discarded as rootstocks although trees of all of them, budded on to Malling No. IX, have been planted out for fruiting to test their possibilities as scion varieties. All the available material of the selected rootstocks has been planted out for propagation in quantity in preparation for extended field trials to test what measure of reliance could be placed upon the results of this preliminary selection and to obtain further information on their potentialities. It is hoped that it will be possible ultimately to eliminate all but the best one or two individuals within each group.

Summary.—Progress in the work of raising and testing apple rootstocks combining good propagation qualities and desirable influences over the scion with immunity from attack by Woolly Aphis is reviewed.

The difficulty of testing on an adequate scale the large number of seedlings now available made desirable some rapid method of determining the potential influence of these rootstocks upon the vigour of the scion in order that individuals from all possible vigour groups might be included among the small number which could be given an extended field trial.

FIG. 1. Photomicrograph of a transverse section of a root of a dwarfing rootstock as illustrated by Malling No. IX. Note the wide bark compared with that in Fig. 2. × 10.

FIG. 2. Photomicrograph of a transverse section of a root of a very vigorous rootstock as illustrated by Malling No. XII. × 10.

The proportion of bark to wood in the roots of apples had been shown in previous work to be correlated with the potential vigour in a number of rootstocks, and the method was applied to the present problem.

These seedlings were divided into seven vigour groups on the basis of the percentage of bark in the root, and fifty-five individuals, all of which had shown promise of being ready rooting and healthy in propagation tests, have been selected for trial under field conditions.

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STUDIES IN THE NON-SETTING OF PEARS

IV.—THE EFFECT OF IRRIGATION AND INJECTION ON THE JUNE DROP OF CONFERENCE PEARS

By F. C. H. GAYNER

Introduction.—Records taken in 1936 of the soil moisture in a pear orchard showed that "the period of the June drop coincided with the beginning of drying out of the soil, though the conditions were by no means those of drought. At this time the leaves and fruits are all expanding rapidly together, so it is at least possible that a general 'tightening up' of the moisture conditions in the tree may encourage the shedding of surplus fruits" (Rogers and Srivastava, 1937). It was planned to follow up this suggestion that the June drop might be due to shortage of water, by trying the effect of supplying the trees with water before and during the period when the June drop normally takes place. Throughout these pear studies comparison has been made of the behaviour of the free cropping Conference with the uncertain cropping Doyenné du Comice.

Before describing the experiments in detail, observations on the comparative behaviour of these two varieties during the June drop should be placed on record. A well defined difference has been observed between the varieties, Conference and Comice, in the way in which the first drop of fruits took place. With Conference all the young fruits began to swell after the petals had fallen, but with Comice the first drop began very soon after petal-fall. Srivastava (1938*a*) has recorded the dates for the various stages through which Conference passed in 1937, namely 18th April full bloom, 3rd

May petal-fall, 13th May first drop began, 20th May peak of the first drop, and the end of the drop on 27th May. With Comice, although there are no exact records for comparison, it was observed that after petal-fall only a small percentage of the fruits remained green and growing, the remainder quickly turned yellow and dropped off. Young fruits of Conference thus differ from those of Comice in appearing to grow for ten days before the first drop begins, while the Comice fruits that are destined to fall in the first drop make no growth at all. Detailed observations on fruit fall have been made by other investigators who reported that pear varieties could be divided into two main groups, those in which the first fall takes place soon after blossoming and those in which it is markedly later (Rudolff and Herbst, 1939).

It was not possible to include both Conference and Comice in the irrigation trial, but Conference appeared very suitable and was therefore used, as described below.

Experimental material.—Twelve Conference trees on Quince A, approximately 20 years old, were available for this experiment. The trees had been grown in a well drained loam on the Malling Series. While the plantation had been kept cultivated, it had received 12 tons of dung per acre in 1937, a crop of autumn sown tares had been ploughed in together with 15 tons of humus from a compost heap in 1938, and in 1940 10 cwt. of high grade shoddy per acre had been applied, in addition to regular 2 cwt. dressings of sulphate of potash and superphosphate (3 cwt.).

The trees for this trial were planted 12 feet apart thus providing a convenient irrigation area of 12 feet square. The experiment however, was planned in such a way that the minimum distance between two experimental trees was 17 feet, so that water given to one tree was not likely to have much effect on any of the other trees.

Procedure.—In 1939 the experiment was begun on the 1st June and as it was feared that there might be a time lag between the application of the water to the soil and its absorption by the roots, it was decided to try the effect of supplying water by direct injection. In the following year the experiment was started at an earlier date and since there was no question of the trees having been short of water, the injection part of the programme was omitted.

It may be noted that absorption of water through the roots and injection of water through the trunk are not similar actions. When water is taken up by the roots plant foods in solution are taken up at the same time, but when water is injected through a hole in the trunk, not only is the existing supply of mineral salts diluted, but the tension in the vessels is broken so that there may possibly be a reduction in the quantity of solution taken up by the roots.

In 1939 the twelve trees used for the experiment were divided into four groups, each of which contained one control and two experimental trees. In 1940 the four control and four irrigated trees were used for the repetition of the irrigation experiment. The treatments were re-arranged in order that any residual effect of the previous years' treatment should be equally divided between the experimental and control trees.

As the trees were large it was not feasible to keep a complete record of the total number of fruits dropped and a sampling method was therefore adopted.

In 1939 the procedure consisted in selecting a branch or branches on the north and on the south sides of the tree and counting the number of fruits on one hundred trusses. The count was started at the top of the branch and the hundredth truss on each side was labelled. Since the upper and lower points were known, it was presumed that there would be no difficulty in locating the intervening hundred trusses. In practice it was disturbingly easy to overlook a small fruit and, as the fruit grew larger, it occasionally happened that more fruit was recorded than in earlier weeks. While it is possible for errors to be both negative and positive, the conditions under which the first record was taken gave a slight bias in a negative direction. When the experiment was repeated in 1940 every truss was painted with a white paint mark and every fifth spur was labelled with a numbered tag. In this way it was possible to keep track of every truss, the only defect being the occasional difficulty of determining the order in which the trusses should be counted.

In the first experiment a weekly count of the number of fruits was taken from 5th June to 14th August, 1939. The picked number and weight was recorded on 13th September. In 1940, in order to economize labour, the records were considerably cut down, being taken only before the first drop on 16th-21st May, before and after the second or June drop on 5th June and 4th July respectively, and finally when the fruit was picked on 10th September. In the second year the scope of the investigation was extended in order to see whether irrigation would increase fruit size.

The water content of the soil on one control and one irrigated site was measured by soil moisture meters of the porous pot type (Rogers, 1935). The use of these meters made it possible to keep a day to day watch on the amount of moisture in the soil and to keep the amount of water above a predetermined figure, by irrigating when the soil began to dry out.

The porous pots were placed in holes dug 3 feet due south of the tree trunk. In the first year the irrigated site had pots buried 15 and 30 inches deep while the control site was provided with a

single porous pot at 15 inches. When the experiment was repeated in the succeeding year, the pots were replaced in the same positions with an additional meter for the 8 inch position on both the irrigated and the control site.

At first the irrigations were carried out by forking up the soil around the tree and then pouring the water on to the loose soil. The top soil absorbed the water in much the same way as a sponge and the water then slowly penetrated to the subsoil. The method, however, was costly and clumsy, and in 1940, in order to speed up the operation, a shallow basin 12 ft. by 12 ft., subdivided into quarters to ensure even distribution, was constructed round each tree. These basins had the great advantage of being permanent so that each irrigation took no longer than the time required to run the water on.

The whole tree injections were carried out according to the method described by Roach (1937). When injecting the whole tree, the injection points must be placed below the fork of the major branches in order that the liquid may be distributed throughout the tree. For trees of the size used in this experiment this meant that the tree had to be injected at two points at least and often three. The operation was carried out by first scraping the bark smooth around the place to be injected and then with a cork-borer removing a circle of bark slightly larger than the hole to be drilled. The hole itself was drilled to a depth approximately equal to half the diameter of the tree. The liquid was supplied under a slight head from a bucket placed in the crotch of the tree. The connection was made with fine rubber tubing, the junction between the tree and the tubing being made by a small rubber bung.

Water cannot be supplied indefinitely through the same hole as the wood vessels become blocked. When this occurs fresh holes must then be drilled.

Volume of water used for Injection and Irrigation.—Both the injections and irrigations were carried out with water obtained from the local water supply. The injected trees absorbed the water rapidly, but the rate slowed down after four days, necessitating the drilling of fresh injection-holes. The quantity of water absorbed is given in Table I.

TABLE I.

WATER ABSORPTION (IN GALLONS).

	Tree 1.	Tree 2.	Tree 3.	Tree 4.
3rd to 7th June	35	31	25	25
Reinjected, 7th to 22nd June	4	5	6	4
Total absorption, 3rd to 22nd June ..	39	36	31	29

At each irrigation, except the first one in 1940, each tree was given 160 gallons of water, which is equivalent to 2·1 inches of rain applied to an area of 144 sq. ft. The irrigations were carried out when the moisture meters showed a reading higher than 20 centimetres of mercury, with the exception of the first irrigation in each year when water was given at the start of the experiment in order to make sure that the trees had an ample water supply.

In 1939, only two irrigations were made, the first early in June, the second in mid-June. These two irrigations probably ensured an adequate water supply to the irrigated trees during the June drop period.

Similar irrigations were carried out in 1940 with an additional one during the middle of May. In the second year also the investigation of the effect of irrigation on fruit size required five more waterings before the fruit was picked, one at the end of June, three in August and one in September. No irrigation was necessary in July, as the rainfall for this month amounted to 3·58 in.

Effect of irrigation on the soil moisture and soil temperature.—The charts in Figs. 1 and 2 show the soil moisture tension measured in centimetres of mercury plotted from the daily readings from May to September for the two years 1939 and 1940. Since the moisture meters are not designed to record tensions above 65 cm. Hg accurately, any readings which exceeded this figure have been put on the graph as maxima. In addition the amount of rain and the equivalent quantity of water used for the irrigations are shown at the bottom of the charts.

A rise in the tension indicates a decrease in the quantity of water in the soil, the actual relationship varying with the kind of soil. For sandy loams of the Malling Series a curve calibrating the soil moisture tension with the moisture content of the soil has been published by Rogers (1939). From this curve it may be seen that a sandy loam holds about 32% of water when saturated to field capacity; at 20 cm. Hg 17%, and when dried out to 65 cm. Hg it only contains 12% of water. The arbitrary maximum of 20 cm. Hg above which the tension was not allowed to rise during the

June drop period thus represents roughly the upper limit of the range within which moisture is believed to be readily available to the tree roots.

During the 1939 June drop period the soil moisture tension on the control plot rose from 18 to 35 cm. Hg at a depth of 15 in. while the two irrigations on the experimental plot prevented the tension from rising above 17·5 cm. Hg. In 1940 the control plot was drier than in 1939 throughout the June drop period, the readings at 15 in. starting at 21·5 cm. Hg and finishing at 50 cm. Hg, while the three waterings on the irrigated plot prevented any of the moisture meters rising above 24 cm. Hg. These readings may be compared with those reported by Srivastava (1938*b*) who found

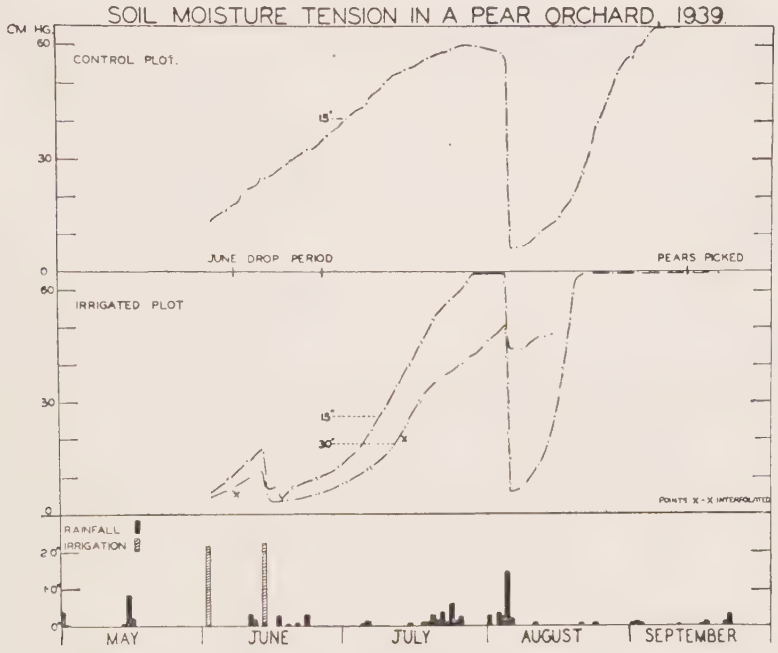

FIG. 1.

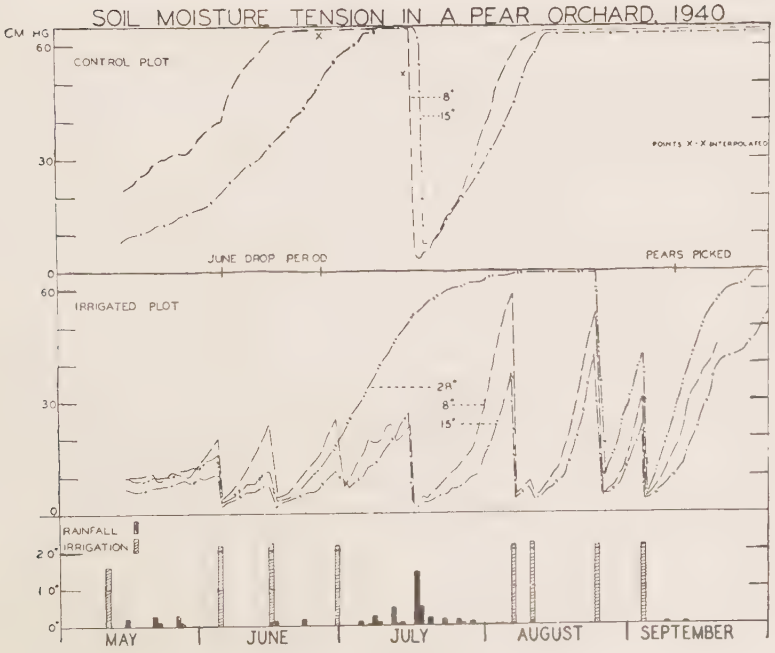

FIG. 2.

during the June drop period in 1936 that the readings, on irrigated land, in the 18 in. position rose from 10 to 19 cm. Hg, and in 1937 two meters at the same depth showed that the tension rose from 28 to 42 cm. Hg in one case and from 30 to 58 cm. Hg in the other. The moisture meter readings for 1939 were thus intermediate between those of 1936 and 1937, while the 1940 readings were similar to those of 1937. It would seem from this that the soil moisture content, during the period when the 1939 and 1940 experiments were being carried out, was normal for the time of year.

It will be noticed that each irrigation resulted in a decrease in the soil moisture tension at the 15 in. level and in some cases at the 30 in. level. This agreed with the general observations at East Malling that an inch of water moistens dry soil to field capacity to a depth of about a foot. This depth, of course, only applies to soils with physical characters similar to those of the Malling Series, the penetration depth varying with the character of the soil. If the soil is not dry before the water is put on, the irrigation water penetrates to a greater depth. This was clearly shown by the irrigation in June 1940, which not only lowered the soil moisture tension at the 15 in. level, but also at 28 in.

The evidence, therefore, indicates that the soil around the irrigated trees was kept well supplied with moisture during the June drop period in both 1939 and 1940, and it would seem unlikely that these trees suffered from any shortage of moisture in the soil.

In 1940 the irrigations were continued during August and September in order to follow up the effect of irrigation on the size of the fruit. These additional waterings were equivalent to 8·4 in. of rain.

Inspection of the 1940 chart of the irrigated plot (Fig. 2) will show that throughout July the soil at 28 in. was getting rapidly drier, although the top 15 in. of soil contained more moisture than the soil below. From this it would seem that the roots of a tree are able to remove moisture simultaneously from a wet and a comparatively dry horizon.

Effect of irrigation on soil temperature.—It is commonly found that the application of irrigation water causes a drop in soil temperature. In this experiment the soil temperature at 8 in. was recorded before and shortly after each irrigation, and a mean fall of 1·5° F. at this depth was shown. It is therefore unlikely that the trees suffered from the cooling effects of the irrigation.

Effect of irrigation on the June drop. —In 1939 the June drop was calculated from the number of fruits which fell during the period 12th June to 3rd July, and in the following year the dates were 4th June to 4th July. The number of fruits which fell towards the end of this period was small and from general observations the chief drop had finished in both years by 26th June.

In order to allow for the differences in the number of fruits which set on the sample branches, the June drop has been calculated as a percentage of the fruits remaining on the tree after the first drop and before the June drop had begun. Table II shows that roughly half the fruits left on the tree after the first drop fell off during the June drop.

Table II.

Mean Percentage of Fruits Falling during the June Drop Period.

Year.	Control.	Irrigated.	Injected.
1939 ..	53·7	64·8	57·8
1940 ..	48·1	43·4	—

It will be seen that in 1939 the treated trees had a slightly higher and in 1940 a slightly lower drop than the control trees, but in neither year was the difference a significant one at the 5% level It would seem therefore that these experiments provided no evidence as far as conditions at East Malling were concerned that lack of soil moisture was responsible for the June drop on Conference pears on Angers Quince roots. A similar deduction was drawn from irrigation trials on orange trees in California in which it was found that during the June drop period there was no great difference in the number of fruits falling from trees growing in wet and dry soils (Furr, Taylor and Reeve, 1940).

In 1940 the mean weight per fruit from the irrigated trees was 0·25 lb. compared with 0·21 lb. from the control ones. This difference in the size of fruit was nearly, but not quite, significant at the one in twenty level. This suggests that more than eight trees are required if conclusive results are to be obtained from trials of the effect of irrigation on fruit size.

Samples of the picked fruit from the irrigated and control trees were used for storage tests, the pears being kept at 45° F. as this was considered to be an average temperature of an ordinary unrefrigerated store. The fruit from the irrigated trees was found to be eating ripe on 14th October, 1940, while that from the control trees did not reach the same stage until a week later, on 21st October (West, 1940). This result is in line with that from a similar experiment in which it was found that

Bartlett pears developed more slowly and stored better when picked from trees growing in a dry than a wet soil (Ryall and Aldrich, 1938).

Summary.—The fruit drop from sample branches on four irrigated and four control trees of Conference was counted during the June drop period in 1939 and 1940. Since the drop was similar on the treated and control trees, no evidence was found that the June drop was caused by lack of soil moisture. In 1940 irrigations were continued until the fruit was picked, but the increase in size of the fruit was below the level of significance. The natural storage life of the fruit from the irrigated trees was shorter than that from the controls.

Acknowledgement.—The author wishes to thank Dr. W. S. Rogers for his interest and advice in conducting this experiment.

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STUDIES IN THE NON-SETTING OF PEARS

V. THE SIZE OF FLOWER IN RELATION TO ITS POSITION IN THE TRUSS

By F. C. H. GAYNER

Introduction.—Observations on the shedding of immature fruits of Conference showed that it took place in two well defined stages, the first a very heavy one of small fruits occurring at the end of May, and the second drop of partially developed fruits taking place about the middle of June. From measurements of the fruit during the growing season it was possible to deduce the general principle that the larger the fruitlet, the greater its chance of growing into a full sized fruit. Moreover it was found that the distribution of the fruit in the different positions in the truss was not a random one, but that the highest percentage set occurred in the fourth, fifth and sixth positions, numbering the King flower as the first (Srivastava, 1938*a*). These deductions were made from readings begun three weeks after pollination had taken place, and the question that then arose was whether the difference in fruitlet size was one of the results of fertilization, or was already present when the flower opened.

Procedure.—This question was investigated in two ways, by weighing blossoms from each position in the truss, and by measuring the size of the corolla in an opened flower. Of the two measurements, weighing was probably more important than corolla size, because weight is more closely related to fruitlet size than the spread of the petals.

Before weighing the flowers the precaution was taken of cutting off the peduncle at the base of the swollen pseudocarp, because of the variation in the length of the peduncle. The junction between the peduncle and pseudocarp was not sharply defined, so that there might have been some variation in the position of the cut, but there was no reason to believe that the experimental error was serious. After the fresh weights had been obtained the blossoms were dried in an oven. In 1939 a drying temperature of 90° C. to 95° C. was used, but this was increased to 95° C. to 100° C. in 1940, so that direct comparisons between the moisture content of the fruitlets in the two years was not possible.

In measuring, the flowers were removed from the inflorescence and gently pressed face down

on the ruler and a reading taken of the maximum and minimum diameter of the corolla. The mean of the maximum and minimum diameters was used as an index of flower size. These readings, taken in the laboratory, are not comparable with those obtained in the field by Srivastava (1938*b*), who measured flowers while still in the truss; in this condition the petals are in contact with each other and therefore are not as fully opened as those flattened out on a ruler. Furthermore, Srivastava did not include the King flower on account of the frequency with which its corolla was pushed in by the surrounding flowers.

Experimental Material.—For the past three years the trusses of flowers have been obtained from the same two trees of Conference, one growing on Quince C and the other on Quince G, both trees being seventeen years old when the first measurements were taken. No distinction was made as to whether the trusses were borne as laterals on one-year-old wood, or as spurs but, as the trees are mature, the great majority of the flowers are spur-borne. The flowers were taken from north and south sides of the tree, care being exercised that the sample should be representative of flowers at all positions along the length of the branch. Small trusses containing seven or less flowers were avoided as it was desired to find out how the flower size varied with regard to position in the truss. The sample was composed of twenty trusses, ten from the north, and ten from the south side of the tree. In 1939 there were plenty of large trusses so that it was possible to use separate samples for flower measurement and fruit weighing, but in 1940 material was not so abundant so that the same flowers had to be used for the two series of observations.

The flowers were collected when all the flowers in the truss were open, and in this way it was hoped to obtain flowers in the same relative stage of development in succeeding years. While no data has been obtained on the length of the period when all the flowers of one truss are opened, it did not appear to exceed three days.

Result.—The result for the mean fresh flower weight and mean flower diameter are shown graphically in Fig. 1. To complete the information figures showing the percentage fruit set obtained by other investigators (Srivastava, 1938*a*, and Thompson, 1939) are shown at the top of the graph. The 1939 curve of "percentage set" is similar in type to that obtained in 1936 and 1937, but 1939 differs from the other two in that the set for the seventh position is higher than in the other two years. The curves obtained by plotting the mean fresh flower weights and the mean flower diameter are comparable, and show that the smallest and lightest flower occurs in the second position in the truss and that there is a gradual increase in the size and weight of the flowers with positions lower down the inflorescence. The fresh flower weights were analysed and it was found that the flowers could be placed in four groups which differed significantly from each other. The groups in order of increasing weight were position 2, position 3, positions 4 and 5, and positions 1, 8, 6, and 7. From Fig. 1, it will be seen that positions 4 to 8 have borne the most fruit, so that with the exception of the King flower, there is quite good correlation between the positions with the heaviest fruitlets and the highest percentage set.

The mean weights of the dried flowers together with the percentage moisture are given in Table I.

TABLE I.

DRY FLOWER WEIGHT AND PERCENTAGE MOISTURE OF CONFERENCE IN 1939-40.

	Position of Flower in Truss.							
	1	2	3	4	5	6	7	8
1939:								
Mean weight of dried flower in grams ..	·034	·026	·029	·033	·034	·036	·036	·037
Percentage moisture	82·8	83·4	83·4	83·1	83·0	83·3	83·6	82·5
1940:								
Mean weight of dried flower in grams ..	·032	·024	·025	·027	·030	·030	·031	·030
Percentage moisture	84·5	84·8	85·1	85·4	84·8	85·0	84·7	84·8

Readings obtained from forty flowers taken in equal numbers from two trees.

Taking the mean of the two years, there was a fairly regular and significant increase in the weight of the flowers from position 2 to position 8. The King flower did not come into the regular progression, for in 1939 it was significantly lighter and in 1940 significantly heavier than the eighth flower. It was also found that the differences between the weights of the flowers in each position were more marked in 1939 than in 1940. With the fresh weight figures the distinction between positions was not so clear cut, but in the main the fresh weight figures confirmed the dry weight results.

The difference in the dry weight of the flowers in the two years was also significant, but this may have been due to the change in the drying temperature, for the analysis of the fresh weights of the flowers did not show any difference between the two years.

Conclusion.—The investigation shows that there are significant differences in the size of the flowers at blossom time, and that with the exception of the King flower it is the heaviest flowers which set the best.

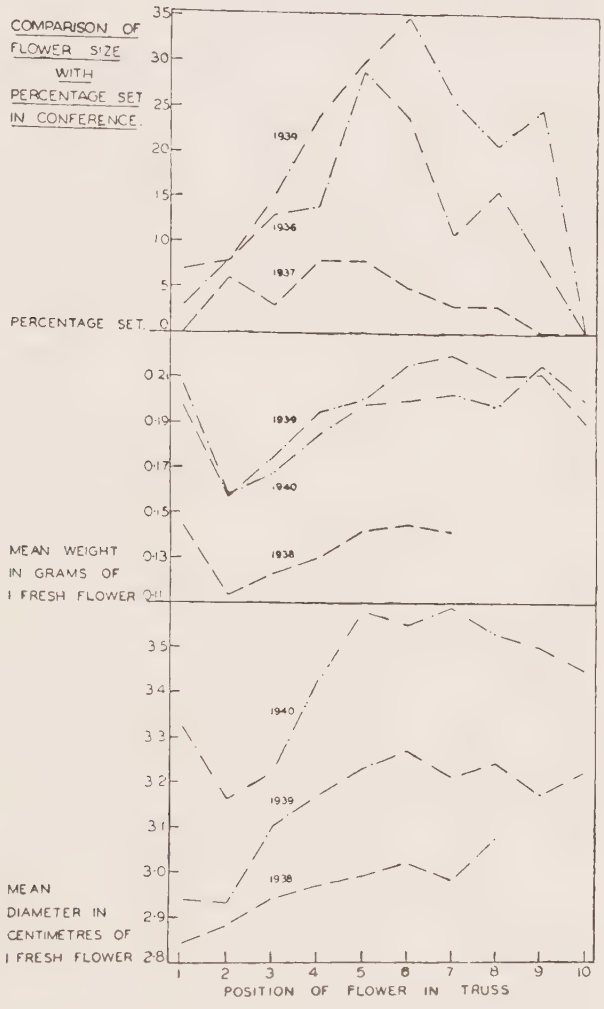

FIG 1.

The differences in fruit size found three weeks after pollination are not therefore solely the result of pollination, but have partially resulted from the initial differences which were already present when pollination took place.

Summary.—The diameter of the corolla and fresh and dry weights of Conference flowers from forty trusses were taken in 1939 and 1940. The flower in the second position (the terminal flower occupying the first) was the smallest and lightest flower and there was a gradual increase in the size and weight of the flowers with positions lower down the inflorescence. The largest and heaviest flowers were found in positions in which the highest percentage set is known to occur, with the exception of the terminal or King flower which in spite of its large size has a low percentage set.

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WEATHER CONDITIONS DURING 1940

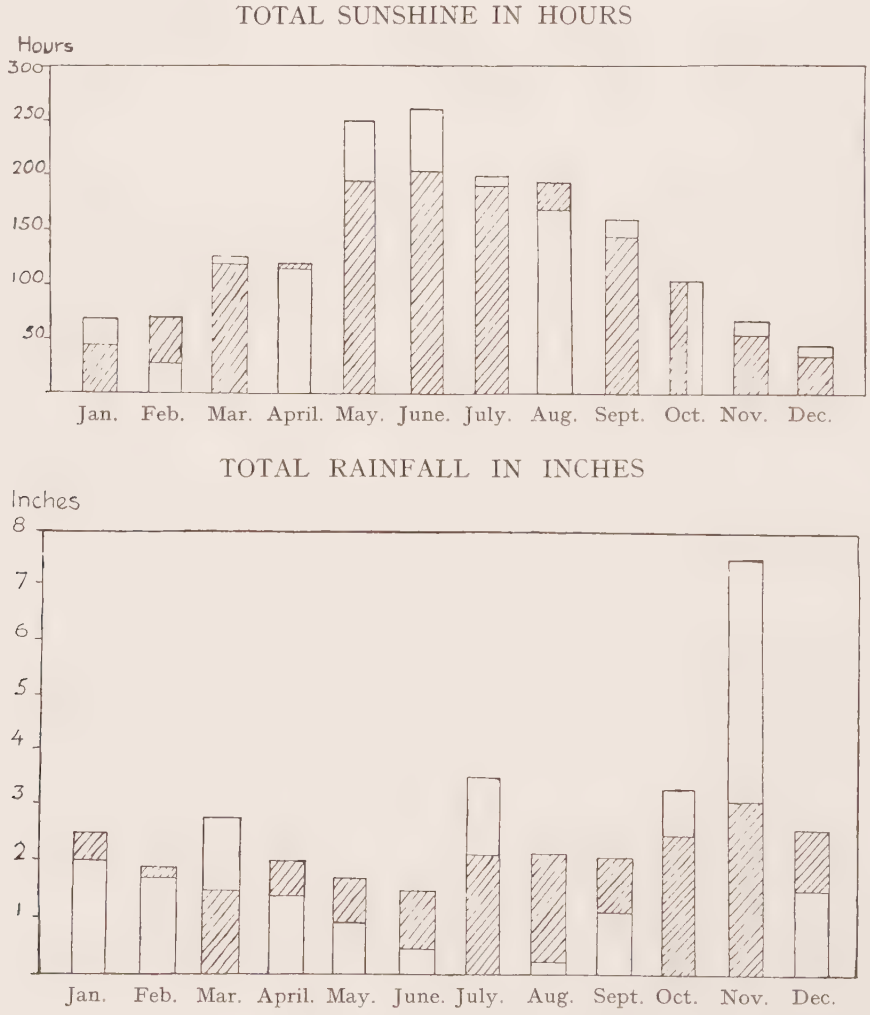
By H. C. CHAPELOW and H. M. TYDEMAN

In all major respects 1940 was a very normal year from the point of view of weather conditions. The year's rainfall of 27·01 inches was less than an inch in excess of the 25 years' average. March and November were outstandingly wet months, the latter in particular having a rainfall more than twice the normal. On the other hand, May, June, August and September were dry, but plentiful rains during July prevented any serious shortage of moisture during the summer.

Sunshine was plentiful, the year's total of 1,598 hours being over 100 hours more than the 25 years' average. The excess occurred chiefly during the summer months.

There were no ground frosts during the period when fruit varieties were in blossom and large crops of all fruits were harvested. There was some delay on many farms in picking the apples, owing to the large crops and labour shortage, but the fine open weather and notable absence of gales during the autumn ensured that they were ultimately gathered in good condition.

During January and February very severe conditions prevailed with ground temperatures at times below zero and considerable falls of snow, causing some delay to farm operations. Apart from this, temperatures were about average through the year and periods of exceptional heat were not recorded. Thunderstorms were prevalent during the latter part of April and during May, while another thundery period occurred during July.



Diagrams showing Total Sunshine and Rainfall during 1940 as compared with 25 years' average. Shaded portion 25 years' average.

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1940.

	Temperature in Screen.					No. of Ground Frosts.	Rainfall.			Sunshine.			Soil Temperature.		
	Mean Maximum.	Mean Minimum.	Highest.	Lowest.	Mean.		Total in inches.	Heaviest fall in a day.	25 years' average.	Total Hours.	Average per day.	25 years' average.	4 inches.	8 inches.	2 feet.
January..	36	23	48	2	29	27	2·08	0·93	2·49	70·4	2·3	46·9	31·3	32·3	35·3
February	42	32	55	18	37	12	1·79	0·36	1·88	32·3	1·1	70·4	34·6	34·8	35·4
March ..	50	36	63	23	43	12	2·93	0·80	1·51	125·7	4·1	120·0	39·8	40·5	41·7
April ..	56	40	70	27	48	6	1·42	0·34	2·09	113·6	3·8	129·7	46·0	45·9	46·5
May ..	65	43	75	32	54	1	0·98	0·29	1·74	250·1	8·1	194·4	55·7	55·0	55·4
June ..	73	49	85	40	61	0	0·43	0·18	1·51	261·3	8·7	204·2	63·2	62·8	62·8
July ..	69	50	80	42	59	0	3·58	1·43	2·14	200·0	6·5	191·1	62·0	61·7	62·9
August ..	71	49	83	36	60	0	0·13	0·08	2·17	169·8	5·5	182·8	61·8	62·0	62·7
September	67	45	85	32	56	3	1·12	0·42	2·14	160·3	5·3	148·6	55·9	44·8	59·7
October	57	40	66	26	48	5	3·32	0·62	2·73	102·8	3·7	100·7	48·2	49·3	52·3
November	52	37	58	26	44	9	7·52	1·27	3·04	67·7	2·3	53·3	43·0	44·4	47·0
December	44	33	52	23	38	18	1·71	0·35	2·79	43·7	1·4	38·2	36·9	38·1	40·5
Totals						93	27·01		26·23	1597·7		1480·3			

PLANT PHYSIOLOGY

REDUCTION OF THE PRE-HARVEST DROP IN APPLES BY SPRAYING WITH A GROWTH SUBSTANCE

By M. C. VYVYAN

Introduction.—Recent work in the U.S.A. has shown that the drop of apples in the period just before picking time can be considerably reduced by spraying the trees with a growth substance. The main results reported by Gardner (1940) may be summarized as follows :

The most effective substances were naphthalene acetic acid and naphthalene acetamide. A concentration of 1 part per million had some effect, and 5 parts per million usually gave good control of drop. The methyl and ethyl esters of the acid were less effective. Indolebutyric, indoleacetic and indolepropionic acids were of still less use. The substance was dissolved in a little alcohol, which was mixed direct with the required amount of water in the tank and sprayed on to the trees. The maximum effect of the spray was usually reached some 5 or 6 days after application and lasted for 2 or 3 weeks. There were varietal differences in response apparently largely due to fruiting habits. Varieties with pendant fruit and long stalks responded best, for the effect depended on the wetting of the stalk and bourse. Some idea of the effect of the spray is given by the following example, where three varieties of apple were sprayed with 5 parts per million naphthalene acetic acid 2 or 3 weeks before picking ; the reductions in drop were as follows : Staymen Winesap from 61 to 23 per cent., York Imperial from 41 to 14 per cent., Delicious from 94 to 14 per cent., while two applications of one part per million reduced the drop in William's Favourite from 79 to 2 per cent. It will be noted that the drop from unsprayed trees ranged from 41 to 94 per cent. which seems much heavier than what would be expected in the United Kingdom.

The period of effectiveness could be extended by spraying at intervals of a few weeks, but too frequent repetitions and too high concentrations lead to damage to trees at time of picking, for the abscission zone in the fruit stalk, where the fruit normally becomes detached, became the " strongest rather than the weakest link in the chain ", so that spurs were pulled off with the fruit. So far these sprays have only been tried on apples.

Earlier application of the spray, such as at petal-fall, did not reduce fruit drop, in fact it rather increased it ; so the method does not at present seem to offer a cure for " June drop ". On the other hand it seems possible that it may reduce drop caused by oil and other commercial sprays. Addition of oil to the spray made the naphthalene acetic acid more effective, and there was no loss in effectiveness when a late codling moth spray of 3 lb. of lead arsenate and 6 lb. of lime per 100 gallons was added. The effect of the addition of lime sulphur and of Bordeaux mixture had not been tried at the time of publication.

Experiments with alpha naphthalene acetic acid sprays were started at East Malling in 1940 in collaboration with members of the Insecticides and Fungicides Section. The results of these preliminary experiments are described below, since the American work appears already to have interested English horticulturists. Enquiries have been received at this Institute as a result of at least one broadcast mention of the subject and it is understood that proprietary substances may shortly be recommended for this purpose. It is therefore thought that such information as is already available should be embodied in a progress report, although the time has not yet arrived when growers can be recommended to adopt the methods, as will be appreciated from the caution given at the conclusion.

Experimental.—Three experiments were carried out with the synthetic growth substance alpha naphthalene acetic acid. The substance was dissolved in a little alcohol and this was thoroughly mixed with the water or spray solution in the tank. The sprays were applied in the usual method with a spraying machine.

The effects of the sprays were determined by counting the fallen fruits under each tree at intervals of a few days. The number of fruits on each tree at the time of spraying and on the successive dates were determined by summing the numbers of these fruits over the appropriate periods and adding the final number found on the tree at the time of picking.

The relative rate of drop during any given period was calculated as follows : If A_1 and A_2 were the numbers of fruit on a tree at the dates t_1 and t_2 respectively, the average daily rate of drop during the period was found from the equation :

$$\frac{(\log A_1 - \log A_2) \times 100}{t_2 - t_1} = \text{rate of drop.}$$

Where the number of days in the time intervals vary, as in these experiments, this is a more convenient method than the use of percentages.

The significance of differences in rates of drop were determined by analyses of variance.

Experiment 1.—Beauty of Bath.—Twenty-one 9-year-old trees of Beauty of Bath which formed the outside rows of a mixed plantation of apples, were used in the first experiment. The sprays were applied on the 24th July, the date on which the fruit on the other trees of Beauty of Bath in the same plantation were picked. The row was divided into seven blocks of three trees each, and one tree, selected at random, in each block received one of the following three treatments :—

(*a*) Control, sprayed with tap water alone.
(*b*) Tap water plus 5 p.p.m. alpha naphthalene acetic acid.
(*c*) Tap water plus $2\frac{1}{2}$ p.p.m. alpha naphthalene acetic acid.

Counts of fallen fruits were made at intervals of 2 or 3 days until 7th August, when the remaining fruits were picked and counted.

TABLE I.

BEAUTY OF BATH. EFFECT OF ALPHA NAPHTHALENE ACETIC ACID ON FRUIT DROP.

Date.	Number of fruit on 7 trees as percentage of original number.		
	A Control.	B 5 p.p.m.	C $2\frac{1}{2}$ p.p.m.
24/7..	100	100	100
25/7..	96	94	94
27/7..	75	66	69
29/7..	56	54	57
31/7..	37	46	46
2/8..	21	41	37
5/8..	13	37	29
7/8..	10	35	26

Period.	Mean rate of drop.				
	A	B	C	$A-\frac{(B+C)}{2}$	Sig. Diff.
24-25/7	1·78	3·31	2·41	−1·08*	·98
25-27/7	5·91	9·44	6·77	−2·19	2·34
27-29/7	6·67	5·14	4·03	+2·09*	1·94
29-31/7	9·01	4·64	4·69	+4·35*	2·87
31/7-2/8 ..	12·19	2·23	4·79	+8·68*	4·41
2/8-5/8 ..	7·60	1·43	3·49	+5·14*	4·02
5/8-7/8 ..	6·74	1·20	2·26	+5·01*	2·57

* Significant.

At the time of spraying, the average number of fruits per tree were 133 on the control trees and 111 and 115 on treatments B and C respectively, and during the first 24 hours the rate of drop was significantly greater on the treated trees. By the end of the fifth day the rate of drop had become significantly lower on the trees treated with growth substance and continued to be so until the end of the experiment. Only 10 per cent. of the fruit remained on the control trees whilst those treated with 5 p.p.m. and $2\frac{1}{2}$ p.p.m. retained 35 and 26 per cent. respectively, between which treatments there was no significant difference. More useful results might have been attained if the trees had been treated a fortnight earlier.

Experiment 2.—Worcester Pearmain.—Twenty-four mature trees of Worcester Pearmain, used as pollinators in a mixed apple orchard, were treated on the 17th August, 1940, some three weeks before the fruit was ready for picking. The treatments were the same as in Experiment 1. There were eight blocks of four trees each, one, chosen at random, under each treatment. Counts of drops were made at intervals of 2 or 3 days and the final crop was counted when the fruit was picked on 6th September.

The average numbers of fruits per tree for each treatment at the start of the experiment were A 260, B 344 and C 251.

The loss by fruit drop was very much less in the Worcester Pearmain than in the Beauty of Bath. By the end of the ninth day after treatment there was a significant reduction in fruit drop

TABLE II.

EFFECT OF ALPHA NAPHTHALENE ACETIC ACID ON FRUIT DROP.

Date.	Number of fruit on 8 trees as percentage of original number.		
	A Control.	B 5 p.p.m.	C $2\frac{1}{2}$ p.p.m.
17/8..	100·0	100·0	100·0
19/8..	99·4	99·2	99·3
21/8..	98·9	98·6	98·5
23/8..	97·3	97·5	97·1
26/8..	96·9	97·3	96·8
28/8..	96·0	97·2	96·7
30/8..	94·4	96·1	96·1
2/9..	93·0	95·1	95·3
6/9..	86·6	93·4	94·4

Period.	Mean daily rate of drop.				
	A	B	C	$A-\frac{B+C}{2}$	Sig. Diff.
17-19/8	·14	·21	·11	·02	·02
19-21/8	·15	·15	·15	·01	·03
21-23/8	·30	·23	·34	·02	·03
23-26/8	·07	·03	·05	·03*	·03
26-28/8	·27	·04	·05	·23*	·03
28-30/8	·39	·25	·12	·21*	·02
30/8-2/9 ..	·25	·15	·09	·14*	·02
2-4/9	·82	·14	·08	·71*	·05
4-6/9	·90	·26	·11	·71*	·06

* Significant.

in the trees treated with alpha naphthalene acetic acid, and this was maintained until the 6th September, when the fruits were picked. There was no significant difference in effects between the two concentrations 5 parts per million and $2\frac{1}{2}$ parts per million.

Experiment 3. Cox's Orange Pippin.—Twenty 11-year-old trees of Cox's Orange Pippin on Malling No. IX were used in an experiment to find out if the drop often induced by the use of a petroleum spray could be reduced by mixing growth substance with the oil. As this drop may occur four weeks after spraying and the effect of growth substance may not last so long, some of the trees were sprayed with growth substance a fortnight after application of the oil spray. The four treatments were :

(*a*) Control—Tap water alone.
(*b*) Oil alone—1 per cent. petroleum spray.
(*c*) Oil mixed with growth substance.
(*d*) Oil followed by growth substance a fortnight later.

The growth substance used was 5 p.p.m. alpha naphthalene acetic acid. The trees were in five blocks of four each, one, chosen at random, under each treatment. The drops were collected at intervals of a few days from 24th July, when the first sprays were put on, until 25th September, when the fruit was picked. As the rate of drop was low and the period long, only the numbers found at weekly counts were used in the calculations and are given in Table III. The first three weeks were treated as a single period.

The differences in rate of drop in trees under treatments A and B show that oil in this particular year did not increase the drop; during one week the drop was actually significantly greater in the control trees. Growth substance reduced the rate of drop during the first four weeks and it made no significant difference whether the substance was mixed with the oil spray, or applied separately a fortnight later.

Mixtures of growth substance with lime-sulphur and with Bordeaux mixture.—No field experiments have yet been carried out to determine whether growth substances can be used to reduce drop caused by lime-sulphur and Bordeaux mixture sprays. As a preliminary, however, coleoptile tests have been carried out with mixtures of alpha naphthalene acetic acid and these commercial sprays. It has been found that curvature induced by the growth substance was not reduced when either

Table III.

Cox's Orange Pippin. Effect of Alpha Naphthalene Acetic Acid and Petroleum Oil Sprays.

Date.	Number of fruits on 5 trees as percentage of original numbers.			
	A Control.	B Oil alone.	C G.S. and Oil mixed.	D G.S. after oil.
24/7.. ..	100·0	100·0	100·0	100·0
14/8.. ..	95·0	94·1	96·5	96·1
21/8.. ..	92·9	90·3	95·5	95·2
28/8.. ..	90·2	88·8	94·1	94·2
4/9.. ..	86·4	85·5	92·5	93·4
11/9.. ..	84·5	83·2	91·8	92·2
18/9.. ..	80·9	80·0	88·7	88·0
25/9.. ..	78·6	78·2	86·6	86·5

Period.	A	B	C	D	A-B	C-D	$\frac{(A+B)}{2} - \frac{(C+D)}{2}$
24/7-14/8 ..	·11	·13	·08	·08	−·02	−·01	+·03*
14/8-21/8 ..	·16	·25	·07	·07	−·09	+·01	+·14
21/8-28/9 ..	·19	·11	·10	·07	+·08*	+·02	+·06
28/8-4/9 ..	·22	·23	·14	·05	−·01	+·09	+·13
4/9-11/9 ..	·13	·18	·06	·11	−·05	−·04	+·07
11/9-18/9 ..	·31	·25	·25	·29	−·06	−·04	+·01
18/9-25/9 ..	·17	·14	·14	·09	−·03	+·05	+·04

* Significant.

lime-sulphur or Bordeaux mixture was mixed with the growth substance. This suggests that these sprays do not inactivate the growth substance and that it will be worth while trying the effect of mixtures in the field.

Caution.—Synthetic growth substances, under certain circumstances tend to produce tumours in plants, though alpha naphthalene acetic acid is one of the least active in this respect. Gardner (1940) suggests that there is little danger of their having similar effects on human beings at the concentrations at which they might be present in sprayed fruit. It was felt here, however, that this is a question that must definitely be answered before the use of growth substances as sprays can be recommended. Experiments have therefore been initiated in collaboration with the Director of the Chester Beatty Research Institute, The Royal Cancer Hospital, to determine whether there is any danger of these substances having tumour-producing, or carcinogenic, effects. At present he writes that "we have no evidence that these compounds are *not* carcinogenic to animals". Until these tests have been completed it is felt it would be unwise to use these sprays on fruit destined for human consumption.

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Summary.—1. The drop of mature fruit in three varieties of apple was reduced by spraying the trees with the synthetic growth substance alpha naphthalene acetic acid a few weeks before picking.

2. The growth substance was effective when mixed with petroleum oil spray and there is laboratory evidence that the substance is not made inactive by mixture with lime-sulphur or with Bordeaux mixture sprays.

3. Tests will be made to find out if alpha naphthalene acetic acid is harmful at the low concentrations used. Until the completion of these tests it would be unwise to use the substance on fruit for human consumption.

Literature cited

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BIOCHEMISTRY

STUDIES IN THE NON-SETTING OF PEARS

VI. THE INJECTION OF PEAR TREES FOR THE DIAGNOSIS OF CARBOHYDRATE AND MINERAL DEFICIENCIES

By F. C. H. GAYNER

A STUDY of the non-setting of certain varieties of pears carried out at the East Malling Research Station, led the investigator to the conclusion that the shy-cropping of certain varieties of pears was a nutritional problem (Srivastava, 1938). A somewhat similar conclusion with regard to apples had been reached in an earlier paper which described the effect of summer rainfall and crop on the yield of apples in the succeeding year (Lees, 1926). The present paper describes an attempt to determine the nutritional status of certain pear trees by both injection and leaf analysis. The varieties chosen for this purpose were Conference, one of the most easily grown commercial pears, and Doyenné du Comice, so shy in cropping, but famed for its high quality. It may be noted that both these varieties are diploids, so that differences in their behaviour cannot be explained by their chromosome numbers (Moffett, 1934).

(*a*) **Diagnostic Injections.**—In the first experiment a 1 per cent. solution of glucose was injected into branches of Comice trees before the flowers had opened in an endeavour to improve the set. The results obtained from these glucose injections were negative, possibly due to the use of too low a concentration or the choice of the incorrect period for injection, because it has been shown that the injection of glucose into a vine just prior to bud-break doubled the number of grapes set (Moreau and Vinet, 1932). But later in the year, general observations of the behaviour of Comice trees suggested that the trouble might be due more to a deficiency of nitrogen rather than of carbohydrate, for the Comice trees were seen to produce an excessive number of flower buds with a low percentage set of fruit, symptoms that with apples are associated with nitrogen deficiency. Any apple grower observing these signs can take steps to put the matter right by spring manuring with a readily absorbable nitrogenous manure such as sodium nitrate, and, provided that the trees are not in too weak a condition, the set of fruit will be considerably improved (Chandler, 1925, p. 183).

For these reasons it was thought that nitrogen deficiency might be responsible for the shy-cropping behaviour of Comice at the Research Station, with the additional possibility of a lack of one or more of the other elements. Accordingly it was planned to carry out a complete series of diagnostic leaf-stalk injections on Comice, and also on Conference, in order to compare the nutritional status of a shy-cropping with a free-cropping pear.

Material.—The Conference tree used for the injections was nineteen years old in 1940 and the Comice trees one year younger, the trees having been planted as maidens. The soil in which they were grown was a well-drained loam and has been classified as belonging to the Malling series (Bane and Jones, 1934). A band of rather more fertile soil ran at right-angles to the tree rows and may partly explain the performance of the Comice on Quince B, but the trees of Conference and Comice on Quince A appeared to be growing in soils of equal fertility. It is of interest to record that a successful grower of pears on a commercial scale was of the opinion that the foliage of the tree of Comice on Quince A was normal for the variety. The total crops picked off these three trees during the past nineteen years is given at the bottom of Table I and illustrates the great difference in yield from a free-cropping and a shy-cropping pear.

Method.—A leaf may show symptoms of suffering from a mineral deficiency in two ways, namely, its size may be reduced, or its colour may be paler than normal. If an element, which the leaf requires for its full development is supplied to the leaf early enough, normal growth and the full development of colour is made possible. The use of injections for diagnostic purposes therefore, depends on supplying the elements to the leaf in such a way that the distribution of the injected liquid is known, and that a comparison may be readily made between the injected and control parts. This can be done by the leaf-stalk method of injection, which has been described by Roach (1938), and is carried out by submerging the cut end of a leaf-stalk in the solution which it is desired to inject. The injection solution, which is absorbed and distributed in a manner to be described later, is contained in a small glass cup which is tied on to the shoot with lead wire. An injected leaf-stalk is shown in Fig. 1.

Since the above description of the manipulations was published, further points of practical importance have been discovered; for example if the leaf-stalk alone is not sufficiently long to reach

the bottom of the cup, part of the lamina at the base of the leaf may be cut off from either side of the mid-rib, until the required length is obtained, the process being illustrated on the left-hand leaf shown in Fig. 1. To ensure success attention must be paid to the time of injection, the type of shoot injected and the position of the injection. It has been found that the best responses are obtained if the injection is made in the latter half of the period of shoot growth. If the injection is made earlier the degree of response is usually not so marked; if the injection is made later the leaves may have ceased growth. In 1940 shoot growth of pears finished early, and consequently Comice had to be injected on 5th and 6th June, while Conference could still be injected a little later, on 11th June.

At present injections have only been carried out on extension shoots with a length of at least five centimetres. The response of spurs to injection has not yet been investigated.

The leaf-stalk through which the injection is made should be that of the highest fully expanded leaf on the shoot. This position is chosen because two leaves below the point of injection will usually not be too old to show some response, while those above will, of course, still be growing actively.

A single injection of each substance is inadequate because of the variation in the symmetry of the leaves and because the maximum response is dependent on getting the optimum quantity of nutrient into the leaf, a process which can only be determined by trial and error. For these reasons at least four replicates of each substance injected should be made.

Fig. 1.

Injected substances.—Compounds containing the elements are introduced into the shoots in aqueous solution at concentrations just below that which will damage the leaves. These concentrations have been determined empirically by previous workers for apples and with the exception of nickel sulphate and cobalt chloride were satisfactory for pears. The exact concentrations and actual salt used to introduce the elements: nitrogen, phosphorus, potassium, magnesium, calcium, zinc, iron, manganese, copper, boron, nickel and cobalt are given in the table of responses to the injections (Table I).

In all cases the solutions were made up with distilled water. To prevent formation of insoluble hydroxide or carbonate a small quantity of sulphuric acid was added to the solutions containing zinc, iron and manganese.

Distribution of the injected liquid.—Before the diagnostic injections were carried out, preliminary tests were made with dye solutions to determine how the injected liquid was distributed. Light Green having proved to be toxic to Comice in 1939, a 0·1 per cent. aqueous solution of Patent Blue was used for the the present injections. Shoots from three trees of each variety were used for the ten replicate injections on Conference and Comice.

The distributions of dye are shown in Fig. 2. The results for Comice fit a 3/8 phyllotaxis diagram better than 2/5, but those for Conference fit a 2/5 diagram slightly better than 3/8 (cf Roach, 1938).

These conclusions from dye injections may be compared with those based on a study of pear inflorescences in which the flowers were found to have a 3/8 arrangement (Rudloff and Wundrig, 1939). Since the inflorescences of twenty varieties including Comice were examined, it would seem that the 2/5 phyllotaxy of Conference is an exceptional one for pears.

In Fig. 2 the portion of the leaf shown black represents the area invariably permeated, while the shaded part showed occasional permeation by the dye when the injection was made though the leaf-stalk numbered 0. It will be seen that the distribution of the dye is not precisely the same on every shoot of the same variety.

Although the diagrams are drawn with a right-handed spiral it should be observed that in the shoots used approximately equal numbers had left-handed and right-handed spirals, both types occurring on the same tree.

From the practical point of diagnosis, the important fact about the distribution of the dye is that it travels to the side of the leaf nearer the point of injection. For example, the second leaf above or below the point of injection is only affected on the side toward the leaf 0, the further side being unaffected. It is thus easy to study the effect of the injection by comparing the two halves of the leaf. The distribution of organic dyes is not quite so extensive as that obtained with simple inorganic salts and this is sometimes very clearly illustrated when a salt is used at a toxic concentration or when it produces an improvement in colour or any increase in growth ; but the general type of injection pattern is unaffected.

Responses to injection.—As indicated earlier, the addition of an element which is lacking or present in insufficient quantity enables the injected part of the leaf to grow more healthily. As a

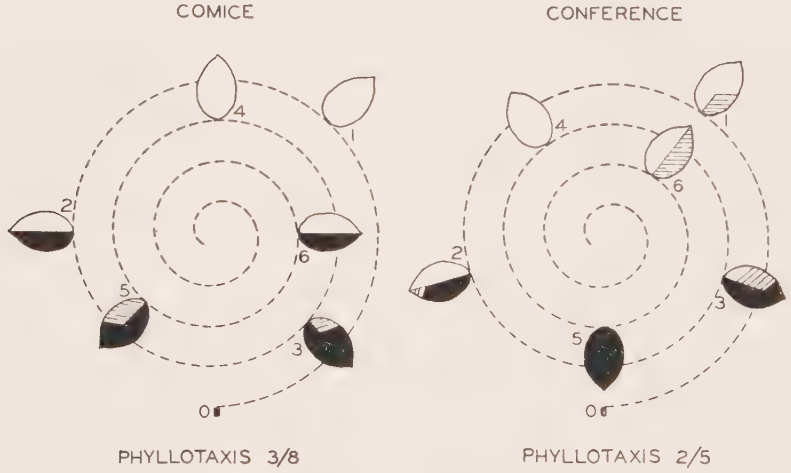

Fig. 2.

Diagram of the distribution of a dye injected through the leaf-stalk numbered 0.

rule the second leaf above and below the point of injection shows the response most clearly. A positive response to an injection may be shown in three ways, either singly or in combination.

(*a*) The injected side may be greener.

(*b*) The injected side may be larger.

(*c*) The mid-rib may be bent by the increased growth of the injected side.

On the other hand if too high a concentration has been used, the sides of the leaves closer to the injection point may be damaged and give a negative response. Injuries of this kind are described later.

In looking at the injected shoots two errors must be avoided. The first is the taking of a negative response for a positive, or *vice versa*. On a casual glance it may look as though a positive response has been obtained, but closer inspection may show that the further side is greener than the nearer, in which case of course the response is negative. The second point is the possibility of overlooking a positive response on a shoot which has received an overdose. This was illustrated by one of the Comice shoots which had been injected with sodium phosphate. The leaves closest to the point of injection showed a slight negative response, but the third and fifth leaf below the injected leaf-stalk were greener on the nearer side. It is therefore advisable when a negative response has been obtained to look at the leaves lower down and higher up the shoot. (See Roach, 1938, p. 34, for distribution of liquid in these leaves.)

The type of damage which may result from the use of toxic concentrations is sometimes peculiar to the injected substance. For example, urea gave a marginal scorch on the permeated side of the leaf. Excess sodium phosphate made the leaf paler, while nickel sulphate produced pink spotting. Both nickel sulphate and cobalt chloride in 0·25 per cent. solutions were toxic, producing initially

black spotting and finally complete death to the leaf. Even the 0·1 per cent. solution did some damage and it would appear that a still more dilute solution should be used in future for pears.

Results.—In recording the responses to the injections, a note was made of the behaviour of each injected leaf on the shoot. By using a simple series of signs it was easy to record any size or colour differences between the injected and control section of the leaf. After these observations a decision was made as to whether or not the response was positive. A shoot to be positive must have either one leaf showing undoubted positive growth, or colour, or if the response is weaker at least two leaves with the same indications.

The first survey of responses was carried out eighteen days, and a second one thirty-five days after the injections had been made. These two complete surveys were carried out by the writer. An independent observer checked all observations which appeared to indicate a positive response. There were no important differences between the two records.

In Table I are given the results of the injections to the three trees. The degree of response of each shoot is indicated by one of four signs as shown below the table.

TABLE I.

INJECTION RESULTS.

Compound injected and its concentration.	Response.		
	Comice on Quince A.	Comice on Quince B.	Conference on Quince A.
1% $CO(NH_2)_2$	+ + + ·	+ + + +	+ + · ·
1% Na_2HPO_4	+ + + +	+ + · ·	— · · ·
1% K_2SO_4	— — — ·	— · · ·	+ — · ·
1% $MgSO_4$	+ + + —	+ + · ·	· · · ·
1% $CaCl_2$	— · · ·	— — — ·	· · · ·
0·025% $ZnSO_4$ +0·025% H_2SO_4	+ + + +	+ · · ·	· · · ·
0·025% $FeSO_4$ +0·025% H_2SO_4	+ + · ·	+ + · ·	— · · ·
0·025% $MnSO_4$ +0·025% H_2SO_4	+ + · ·	+ · · ·	— · · ·
0·025% $CuSO_4$	· · · ·	— · · ·	— · · ·
0·1% H_3BO_3	+ + + ·	+ + · ·	— · · ·
0·1% $NiSO_4$	+ — · ·	+ · · ·	· · · ·
0·1% $CoCl_2$	Toxic concentration.		· · · ·
	1922-40.	1922-40.	1921-40.
Total weight of crop	287 lb.	390 lb.	1,030 lb.

Degree of response: + Strong response. + Mild response. · No response. — Negative response.

From Table I it will be seen that the tree of Comice on Quince A appears to be lacking adequate supplies of nitrogen, phosphorus, magnesium, zinc, iron and boron. There are also indications that the tree requires larger amounts of manganese and nickel. Exactly the same elements gave positive responses with the tree of Comice on Quince B, but the degree of response was milder, and the zinc, manganese and nickel responses were only obtained on single shoots. Conference, on the other hand, provided a sharp contrast, for positive responses were found only with two elements, namely two mild responses with nitrogen and one response with potassium.

It may be noted that there was no indication of any shortage of potassium in the Comice trees, but Conference gave the opposite response showing a slight indication of deficiency. This difference in potassium requirement may be varietal or due to the fact that Conference was carrying a heavy crop while Comice was not.

In view of these results, the response of the pear Beurré Hardy to branch injections of water, 0·5 per cent. urea, and 0·5 per cent. potassium phosphate may be recalled (Srivastava and Roach, 1937). Urea alone doubled the amount of shoot growth, while urea plus phosphate injected branches made seven times as much growth as the controls. Since there was a serious fruit fall on the urea and phosphate injected branches, Srivastava and Roach were uncertain whether the increased growth was due to fruit thinning or injection. But as Comice on the same plot as the Buerré Hardy has now been shown to be suffering from a shortage of both nitrogen and phosphorus, the increased growth of Hardy may well have been a positive response to the urea and phosphate injections.

(*b*) **Leaf Analyses.**—While measurements were being taken on some Comice trees growing in the same plot as those used for the diagnostic injections, marked differences were observed in the

behaviour of opposite sides of one of the trees. The first difference noted was in the appearance of the foliage, for on one side the leaves were glossy and deep green in colour, contrasting with those on the other side which were smaller, lustreless and yellowy-green. The paler leaves were similar to those borne on the other Comice trees growing nearby. It soon became apparent that the branches bearing the more healthy foliage were making greater shoot growth than those on the other side. A photograph of the tree (Fig. 3) taken after a severe drought, illustrates two further differences which were noted, namely that there was less defoliation and a heavier crop on the vigorous than on the weak branches. When this crop was picked it was found that the vigorous side of the tree produced 140 pears, weighing 30·8 lb., while the side which lacked vigour had only 4 pears, weighing 0·7 lb. The earlier defoliation on the weak side than on the vigorous may in itself be a symptom of deficiency, for it has been shown by sand culture experiments that apples, gooseberries, black currants and raspberries from which nitrogen or phosphorus was withheld lost their leaves earlier than those plants which were given a complete supply of nutrient materials (Wallace, 1925 *a* and *b*).

Examination of the tree showed that the vigorous branches appeared to be in direct vascular connection with a single large root arising above the union of scion and rootstock. Thus, one side of

FIG. 3.

Comice tree with vigorous branches on the right and weak ones on the left.

the tree was almost certainly established on its own roots and not on the original Quince C rootstock upon which it was budded.

The diagnostic injections described above compared the mineral deficiencies between two trees of Comice and also between the two varieties, Comice and Conference. The occurrence of healthy foliage, vigour, crop and mild defoliation on one side of a tree and of the opposite conditions on the other provided excellent material for determining how far these horticultural differences were associated with peculiarities in mineral composition.

Leaf samples from the two halves of the tree were therefore examined in the Biochemistry Section by the oxy-hydrogen and oxy-acetylene flame spectrographic methods. The most striking difference was in the manganese content which was higher in the healthier part of the tree, a result in harmony with the injection results already mentioned. There was a similar definite but less marked difference in the potassium content, but there is insufficient data to decide how far such a difference is of importance. The iron lines were too weak for accurate comparison. These facts are sufficient to prove the difference in mineral nutrition between the two halves of the tree and justify further work.

Summary.—The nutritional status of certain trees of the free-cropping pear, Conference and the shy-cropping pear, Doyenné du Comice was compared by the leaf-stalk method of injection by introducing solutions of compounds of twelve of the elements essential for plant growth. It was found that Comice gave positive responses to solutions containing compounds of nitrogen, phosphorus, magnesium, zinc, iron and boron, while Conference only gave a slight one to nitrogen. The responses were stronger on the poor Comice than on the relatively good tree.

Spectrographic analysis of leaves from the vigorous and crop-bearing side of a Comice tree suggested that its mineral nutrition was better than the other side where the reverse conditions were found.

The evidence although tentative would seem to indicate that defective mineral nutrition may be one cause of shy-cropping.

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MYCOLOGY AND BACTERIOLOGY

NOTES ON PLANT DISEASES IN 1940

By H. WORMALD

Non-Parasitic Disorders of Fruit Trees.—*Winter Injury.*—During 1940 the most notable meteorological feature affecting fruit-trees was the long period of severe frosts early in the year. As a result of this the bark of many apple and pear trees became badly cracked. Much of the cracking tended to become healed during the summer, by the development of callus below, or at the edges of, the fissures. Whether the damage was any more than temporary will be seen in the behaviour of the trees in future years. On some pear trees buds were so severely injured that they failed to develop, and abortive blossoms found on black currant bushes were probably also to be attributed to the winter frosts. Cropping, however, was little affected, and in fact there were good crops of most fruits, particularly apples, pears and plums.

Dwarf Lateral Scorch.—The disorder of raspberries known as Dwarf Lateral Scorch, when buds fail to develop or grow out into short infertile shoots, was either absent or negligible. No instances were noticed on this Station, and no enquiries were received about it, although it had been very severe in 1939. There is evidence from field observations and from experiments that this trouble is brought about by the relatively high temperatures during mild winters. Its absence during 1940 after the very severe winter frosts confirms this conclusion.

Hail Damage.—Towards the end of July a very severe hailstorm caused much damage to fruit and hops in the neighbourhood of Brenchley. Hop leaves were lacerated and the young hop cones

were bruised. Plums too were badly bruised and cracked in consequence ; later this was followed by severe Brown Rot infection, the fungus getting into the fruit through the injuries caused by the hail.

Storage Scald.—In December, apples (Bramley's Seedling) showing the typical discoloration of Storage Scald (or Superficial Scald) were received from Paddock Wood. The discoloration was almost invariably round the eye end (as is usual in this disorder), and only on one of the specimens sent was the browning on the side also. The damage was not serious in this particular instance. This trouble can be prevented to a large extent by the use of oiled wraps, and such wrapping is essential if the fruit is to be placed in gas-storage.

Parasitic Diseases.—*Apple Canker.*—Early in January, 1940, an apple tree (variety Pedro) was found to be very badly cankered. One of the main limbs had a large canker just above the crotch and another higher up. These cankers bore numerous pustules of the Fusarium stage of *Nectria galligena*, the Apple Canker fungus. At the time of these observations (8th January) there was a short break in the long period when very low temperatures were experienced. For two and a half weeks previously there had been an almost continuous frost with very low temperatures on certain nights ; thus the screen temperature on 2nd January was 17° F. and on 30th December as low as 12° F., so it seemed to be an opportunity for ascertaining whether the Fusarium spores could survive such low temperatures. It is unlikely that the pustules were actually produced during that period, and the spores were probably developed before the very cold spell started. The spores on microscopic examination seemed to be uninjured, so some were left in a drop of water overnight at the ordinary temperature of the laboratory (60°-65° F.). Within 24 hours many had germinated and produced germ tubes several times as long as the spores from which they grew. The spores of the canker fungus, therefore, are not killed at such low temperatures, and merely await favourable conditions for causing further infection.

Later in the year an instance of severe cankering of young Cox's Orange Pippin trees was observed in a grower's plantation. About fifty of these trees had been planted in the winter of 1938-9 and they had been de-feathered in the late winter or early spring. When examined (May, 1940) about half of them had cankers on the main stem and some of the cankers had completely girdled the trees. This made necessary cutting back those trees below the cankers to allow new stems to develop. Where the cankers had not girdled, and had not encroached too far round the stems, they were cut out. At the middle of each canker was an old cut where a side shoot had been removed during the de-feathering about a year previously, and the fungus had evidently entered the stems at such pruning cuts. These observations suggest that when young apple trees are planted, and before any branches are pruned away, care should be taken to examine any older trees in the vicinity and to cut out all cankered parts, burning them promptly since such cankers are a possible source of infection for the young trees.

Papery Bark Canker.—This trouble often occurs on apple trees after they have been top-grafted. In April, 1940, a tree of Newton Wonder which had been top-grafted with Laxton's Superb in 1935 was dug up because of a large papery bark canker on the trunk. A few fructifications of the Silver Leaf fungus, *Stereum purpureum*, were present on the stem. The association of this fungus with the papery bark condition has been observed frequently, and often the fungus can be isolated from the discoloured wood of such trees when Stereum fructifications are not present. It has been found, however, that if such trees are dug up, or cut down and the stems left on the ground, or piled up on one side of the orchard, a rich crop of fructifications will develop. This indicates that it is bad practice to leave such stems lying about, for they will serve as a source of infection; they should be burnt immediately. Infection by *Stereum purpureum* is a frequent cause of failure in top-grafting, and frame-working is now recommended, for it affords less open surface for infection.

Brown Rot.—Large crops of tree fruits were general in 1940, but towards the end of the season there were severe outbreaks of Brown Rot. Fallen fruits particularly became infected with *Monilia fructigena* and were left on the ground to spread infection ; it was found also on plums which had been thinned, the " thinnings " being left on the ground to rot. Owing to a glut of plums in 1940 many were left unpicked, and as they ripened they became infected with *Monilia fructigena* and *M. cinerea* and remained on the trees as mummied fruits within which the fungi passed the winter. Quantities of such mummied plums were seen on the trees during the winter, and, if the weather is favourable for infection in 1941, spores from them will probably cause severe infection again. Those bearing *M. cinerea* are particularly dangerous for this fungus is able to infect plum flowers to cause blossom wilt, and also the young shoots to produce Wither Tip and Spur Wilt.

Early in 1941 dead spurs of Conference pear, in an orchard at East Peckham,* were seen to be bearing pustules of *Monilia cinerea* on the axis of the spur and on the dead flower stalks, remains of which were persisting, thus indicating that blossom wilt had occurred in the spring of 1940. Blossom

* The specimens were collected by M. H. Moore.

Wilt, though common in apples, is unusual in pears and it had not previously been observed on the variety Conference. Within a few yards of the pear trees were plum trees bearing many mummied fruits, some with the blossom wilt fungus.

Storage Scab of Apples.—In February attention was drawn to a serious spotting of Cox's Orange Pippin apples as they were taken from gas storage. The spotting proved to be Storage Scab, which develops during storage from infection by the Apple Scab fungus, *Venturia inaequalis*. Storage Scab is common in America and on the Continent, and it has been found on apples from ordinary cold storage in this country.* That it may develop on apples in gas storage appeared to be a fact not previously noted, so a description of its occurrence under such conditions was published in the *Gardeners' Chronicle* (25th May, 1940). The article was noticed by A. R. Lugeon, a Swiss horticulturist, who wrote to that Journal to say that Storage Scab ("Tavelure tardive") was very common in Switzerland, and recommended late spraying with "a weak solution of carbonate of copper". In Britain the usual recommendation is the application of colloidal sulphur or a sulphur dust to the fruit as it approaches maturity, usually towards the end of August, or beginning of September. The earlier routine spraying, "pre-blossom" and "post-blossom," directed against early infection of scab, are of course also a help in preventing late infections, that result in Storage Scab. The late application should be one that leaves no evident visible deposit on the fruit at the time of picking.

Grey Mould.—Grey Mould, *Botrytis cinerea*, was found on a number of host plants. In particular it was seen associated with an eye-rot of apples described elsewhere (see p. 59). In May this fungus was found on a dead apple spur (Bramley's Seedling), which had borne an apple in 1939, and probably infection of the spur took place through the fruit. Such spurs doubtless serve to carry the fungus over the winter to cause further infection the following year. Grey Mould is sometimes the cause of serious wastage in strawberries. In June a little appeared on strawberry plants on this Station as they were approaching maturity, but the weather remained dry until the picking was finished and the rot made little progress even on certain irrigated plots.

Pear Mildew.—Powdery Mildew, though very common on apple and some varieties of quince, is comparatively rare on pear. In July a single pear shoot with mildew was found in a garden at Maidstone. The tree was on a fence, and just over the fence was an apple tree very severely affected with mildew; it seems probable, therefore, that the pear became infected from the apple. The same powdery mildew, *Podosphæra leucotricha*, infects apple, pear, and quince, so one host may serve as a source of infection for the others.

Angular Leaf Spot.—A spotting of apple leaves characterized by the angular shape of the lesions has recently been reported from various localities in the South of England. (See Report for 1939, p. 63.) It had previously been recorded on the Continent, where it was attributed to a fungus found on the spots. Observations at East Malling,† and by Mr. W. C. Moore, at Harpenden,‡ during 1940, showed however, that the spots were really caused by a frog-hopper, and it is now assumed that the fungi which appear later on the spots are saprophytes living on the tissues killed by the insect.

Wilting of Plum Shoots in Layer Rows.—From time to time reference has been made in these Reports to a wilting of the shoots in the layer rows of various plum and cherry varieties used as rootstocks. In 1940, it was more serious for in the variety Brompton, about 40 per cent. of the shoots were killed and in St. Julien A, over 50 per cent. There was a little wilt in certain cherry rows also. The disease is attributed to a fungus, a species of *Cylindrocladium*. Specimens of cherry received from Surrey in 1940, showed a similar shoot wilt and the same fungus was isolated from them. It would seem that the fungus is not confined to the plum and cherry for isolations from wilted lupin plants, under observation as a cover crop, yielded the same organism, so that the possibility of other host plants being sources of infection cannot be ignored. Trials are being planned in an investigation of methods of control of the disease in the nursery rows.

Sooty Mould of Plum.—On certain plum trees on the Station, particularly the variety Utility, the fruit as it approached maturity appeared to be very dirty, and at picking time the "dirt" very readily came off on to the pickers' hands. This "dirt" was found to be a sooty mould, a species of Coniothecium. This fungus, which is distinct from that causing Sooty Blotch, is quite superficial and is not a parasite; it does not attack the fruit but merely grows on the honey-dew exuded by aphides. The species of aphis present in this instance was the Mealy Plum Aphis, *Hyalopterus arundinis* F. The affected fruit was rough to the touch and when rubbed with a moist finger the soot-like deposit was easily removed; on microscopic examination it was found to be composed largely of the dark brown cell-clusters of the mould. Since the mould is dependent on the honey-dew secreted by aphides it follows that the best means of controlling it is to keep the aphides in check.

Rust on Black Currant Leaves.—The Black Currant Rust, *Cronartium ribicola*, rarely causes

* See the *Annual Report* of this Station for 1934, p. 232.
† See this Report, pp. 24 and 65.
‡ *Trans. Brit. mycol. Soc.*, 24 (1940), 345-6.

severe damage. In 1940, however, it appeared earlier than usual and on this Station it was found early in July. Towards the end of the month leaves very severely infected, some with the under side nearly covered with the rust stage, were received from Tonbridge. In the first week of September it was found affecting nearly all the leaves in a plantation of Baldwin's Black on a farm at East Malling, some of the leaves being completely covered with the felt-like layer of fructifications of the teleutospore stage of the fungus. Growers may be reminded that this rust passes one stage of its life-history on five-needled pines, particularly the Weymouth Pine (*Pinus Strobus*) so that currants growing in the vicinity of such pines are likely to become infected earlier in the season, and thus to be more severely affected, than bushes growing where there are no five-needled pines near them.

Gooseberry Leaf Spot.—Early in July gooseberry leaves and fruits, from bushes in a plot of mixed varieties, were examined. The leaves were severely spotted and turning yellow, and lesions bearing conidia of the leaf spot fungus, *Pseudopeziza Ribis*, were present on leaf-stalks and fruit. Few spots on the fruit bore conidia, and others, which were small, dark with ill-defined margins, but with a raised spot in the centre, were apparently the early stage of fruit infection. This disease is usually confined to the leaves and may at times cause serious defoliation. These observations show that in severe infection the fruit also may become spotted.

American Gooseberry Mildew.—It is to be noted that this disease sometimes affects species of *Ribes*, other than the gooseberry, and is occasionally found on black currant and red currant bushes. At least one ornamental species of *Ribes* is also liable to be attacked in this country. In August, shoots of *Ribes fasciculatum chinense* were found bearing mycelium of American Gooseberry Mildew, *Sphærotheca mors-uvae*.* On the leaves it was white, with chains of summer spores, but on the axis of the shoots it was turning brown, as it commonly does on the gooseberry. This mycelium extended for about 2 inches from the tip downward along each shoot ; the affected shoots showed some distortion, and badly infected leaves were distorted and small. The possibility of cross-infection between the fruit-bearing and the ornamental species of *Ribes* should thus be borne in mind, especially when planning a garden.

Bacterial Blight of Walnut.—In July it was noticed that Bacterial Blight, caused by *Pseudomonas Juglandis*, had appeared on a row of young walnut trees on this Station. There was little fruit as the trees had hardly come into bearing, but the leaves on certain trees were severely spotted. These trees were all of selected English varieties and the observations indicate that some of these varieties are as susceptible to blight as those of foreign origin. A tree of the variety Patching was the only one with any appreciable crop and about 50 per cent. of its fruits were affected. This variety produces clusters of nuts suitable for pickling, and earlier in the season, at the time when they would have been ready for pickling, they were clean. All the trees were sprayed with Bordeaux mixture to check the spread of infection to the young shoots, for the organism overwinters in the lesions on the shoots.

Summary.—Notes are given on certain plant disorders and diseases noticed in 1940. They include mention of damage caused by severe frost, Blossom Wilt (*Monilia cinerea*) of Conference pear, Storage Scab on gas-stored apples, an Eye Rot of apples associated with Grey Mould, a severe outbreak of Shoot Wilt in layer beds of plum varieties used as rootstocks, American Gooseberry Mildew on an ornamental species of *Ribes*, and severe Bacterial Blight on trees of English varieties of walnut.

BACTERIAL BLOSSOM BLIGHT OF PEAR TREES

By H. WORMALD and H. B. S. MONTGOMERY

In recent years frequent enquiries have been received about a disease of pear trees affecting the blossom buds and the flowers, and the same disease has appeared from time to time, sometimes to a rather serious extent, on this Station on bush trees and on cordons. It is chiefly characterized by a blackening and wilting of some or all the flowers of a truss, the discoloration extending into the stalk of the cluster of flowers and sometimes into the older parts of the spur, but often a flower bud and its surrounding scale leaves turn black soon after the bud begins to swell, and the flowers themselves do not open at all or expand irregularly and imperfectly.

When pieces of affected flowers and spurs are teased out in water and examined under a microscope numerous bacteria are seen to ooze out of the tissues into the water, sometimes accompanied by many small spores of a fungus which is often also present. The almost constant association of bacteria with the discoloration and death of the blossom trusses suggested that they were the cause of the trouble, and attempts were made to isolate the organism concerned with the disease, so that its cultural characters could be studied for its identification, and inoculation experiments carried out

* The writer is indebted to Mr. N. H. Grubb for these specimens.

to determine whether it was really parasitic and able to produce the disease. A number of different organisms came up on the culture plates but most frequently one appeared which, from its behaviour in culture media, seems to be closely related to, if not identical with, an organism that has been found to cause bacterial diseases of plum and cherry trees, and has been named *Pseudomonas prunicola.*

Inoculation experiments carried out on pear inflorescences with this organism, isolated from pear flowers and spurs, at first yielded negative results, but in 1940 it was found that pear flower trusses could be infected when inoculated with pure cultures of the organism, some of these infections resulting in the complete blackening and withering of the flower clusters.

The disease has been found on most of the varieties of pears commonly cultivated in this country, but some appear to be more susceptible than others. On this Station, Durondeau and Pitmaston have been found most often attacked, but Catillac in some years is also seriously affected.

Specimens showing this disease have been received from various localities in Kent and from Essex ; in 1938 specimens sent to us from Jersey appeared to be affected by the same disease, but in isolation tests the organism that appeared on the culture plates was different from that usually associated with the disease.

About thirty years ago a disease with similar symptoms appeared in the West of England and a bacterium found associated with it was shown by inoculation experiments to be able to cause infection of the flowers. This organism (which was given the name, *Bacillus Barkeri*) and the one studied at East Malling behave differently in culture media, so they are considered to be distinct species. Moreover in experiments at East Malling, yet another organism gave successful results in inoculation experiments. It appears then that the general symptoms described may be caused by more than one species of bacteria.

Another disease of pear trees with somewhat similar symptoms and known as Blossom Wilt is caused by *Sclerotinia laxa* (*Monilia cinerea*), one of the Brown Rot fungi. On pear trees this disease has been met with less frequently than that resulting from infection by bacteria and up to the present time has been less serious. It is different from the bacterial blight in that the discoloration is less intense and that infection always occurs (so far as observations have gone) through the open flowers so that the wilting is not noticeable until about a fortnight after the flowers open, while in the bacterial disease the flowers are usually affected, either before they open, or soon after expanding.

A bacterium similar to that obtained from the flowers and spurs has been isolated from leaf spots and from spots on the fruit, so that it seems probable that one and the same species of organism can attack flowers, leaves and fruit. Full confirmation of this is required, however, although it has been found that the bacterium isolated from the spurs is able to produce lesions on pear fruits, and that isolations from leaf spots and fruit spots are able to cause a blackening of the flowers.

It is not known how infection arises, but the fact that infection so often shows very soon after the buds expand, suggests that the organism has passed the winter in, or on, the buds, and becomes active when conditions become favourable for its development. This, again, suggests that the buds become infected from the spurs infected the previous year. As a means of control it is desirable, therefore, that all affected spurs should be cut out early in the year, as soon as the disease is noticeable, for they contain dense masses of the parasitic organism and are thus a possible source of infection not only for next year's buds, but also for the current year's leaves and fruit.

As more information is required regarding the severity and distribution of this disease, growers are asked to be on the watch for the symptoms mentioned and to send any suspected specimens to this Station for diagnosis.

Summary.—A bacterial blossom blight of pear trees is recognized by the blackening and withering of the flowers, and sometimes the whole spur is killed. The organism generally found associated with this disease has been found by inoculation experiments to be able to produce the disease on pear trees.

THE GREY MOULD OF FRUIT AND HOPS

SOME POSSIBLE SOURCES OF INFECTION

By H. WORMALD

The range of host plants of Grey Mould, *Botrytis cinerea*, is probably greater than that of any other parasitic fungus, for under conditions favouring its development it is able to infect plants of many families. Grey Mould is particularly destructive to soft parts of plants such as the fruits of the vegetable marrow, pods of dwarf bean, and leaves of lettuce, but during wet weather plants of a less sappy nature often become affected, and leaves, shoots, flowers, and fruit may bear this grey powdery mould. In the flower garden, for instance, it is frequently seen on rose buds, and on the flowers of

other ornamental plants. Shrubs, such as lilac and flowering currants may have their shoots killed by Grey Mould, and recently a shoot wilt of *Prunus triloba* var. *floro pleno* in this country has been attributed to infection by Grey Mould (W. C. Moore, 1939). The same fungus has been found on stems of young apple trees and on the roots of " heeled-in " apple stocks.

Grey Mould is one of the commonest causes of rot in fruit, and has been observed on apples, pears, plums, cherries, quinces, strawberries, raspberries, loganberries, grapes and figs. Infection may occur before they are picked, but it is also frequently found on stored fruit; thus stored apples are often damaged by it and it has occurred on plums during cold storage. On strawberries the rot may cause serious wastage (as high as 30 per cent.) if there is wet weather as the fruit is maturing. On gooseberry bushes it attacks not only the fruit, but also the branches to cause the so-called Gooseberry Die Back, and it sometimes infects and kills raspberry canes. A die-back of the shoots of fig trees is brought about by the same fungus.

A disease of apples when they are about half grown appears to be a result of infection by *Botrytis cinerea*. Towards the end of July, 1940, a number of apples on this Station showed a dark discoloration at the eye end, resembling the early stages of Eye Rot caused by the Fusarium stage of *Nectria galligena*, the canker fungus (Salmon and Wormald, 1915). A few days later apples with a similar discoloration were brought in from Sittingbourne, and others sent from Cambridge.* No trace of Fusarium could be found on any of these specimens, but the calyx lobes bore fructifications of *Botrytis cinerea*, suggesting that this fungus was the cause of the discoloration. Some of the apples were placed in moist chambers in the laboratory so that any further development of the fungus could be observed. Most of them showed no further increase of the discoloured areas, but others developed a rot, extending eventually through the whole fruit, and fructifications of the Grey Mould fungus appeared on the surface of the rotting fruit. These observations suggested that on some of the apples a protective layer had been formed, preventing further growth of the fungus, whilst on others, on which such a layer had not yet been produced, the mould was able to continue its development.

This eye rot was noticed during wet weather after a period of several dry weeks, and it is suggested that the calyx lobes soon became thoroughly dry and withered, but that later they became soaked with rain and so formed a very suitable substratum for Botrytis, which then extended into the fruit itself. This eye rot not only disfigures the fruit but, given suitable conditions for the growth of the fungus, it would appear to be able to develop into a more extensive rot.

A similar eye rot of apples has recently been observed in New Zealand†, where it is also attributed to *Botrytis cinerea*. The report states that, " A disease known in Nelson as ' eye-rot ' or ' dry eye-rot ' common in Jonathan and Cox's Orange varieties, has been responsible for the rejection of fruit for export because of the danger that the fungus responsible, *Botrytis cinerea*, might continue growth." Affected apples were held in cold storage for five months, but no further development of the fungus occurred, and "the evidence obtained so far would seem to indicate that it would be safe to export fruits exhibiting discoloration at the calyx."

On hop plants Grey Mould has been known to cause a leaf blotch and a rot of the tip of the cones (Wormald and Cheal, 1926), as well as a flecking or spotting of the cones. The leaf blotch and cone tip rot have been but rarely seen and probably only occur under circumstances exceptionally favourable for the development of the fungus. The cone " fleck " is perhaps more general although it has been reported on a few occasions only ; but as it bears some general resemblance to Downy Mildew infection of the cones it may at times have been confused with the latter. Salmon and Ware (1938) reported it as occurring on Tutshams, Cobbs and Tolhursts at Biddenden in 1937 ; it was found on two Mexican seedling hop plants on this Station in September 1939, and a few days later hops showing similar flecks were received from a farm at Maidstone.

As Grey Mould has such a wide range of host plants it may be assumed that some of these serve as sources of infection for fruit and hops. As already mentioned cultivated garden plants often bear Grey Mould, but it has been observed on wild plants also. In autumn 1938, it was found attacking the flower heads of a dandelion plant growing as a weed in an apple plantation at East Malling. More recently, in the summer of 1940, it was seen on leaves of black bryony in a hedge, near East Malling, and a few weeks later on the fallen cupules of the sweet chestnut where it formed a dense layer of Botrytis fructifications on the inner surface of the cupules, and on the fruits of brambles in hedgerows.

One hedge in which affected brambles were found was along one side of an apple orchard, and, at the time the apples were being picked, there were dozens of bramble fruits bearing fructifications of Grey Mould ; these must have been scattering myriads of spores some of which doubtless fell on the apples and were carried into the store ready to set up Grey Mould rot.

* I am indebted to Dr. W. A. R. Dillon Weston for sending these specimens.

† *Fourteenth Annual Report of the Department of Scientific and Industrial Research*, New Zealand, 1939-1940 1940), p. 47.

It is not known to what degree any particular strain of the fungus on one host is able to attack other plants, but wherever Grey Mould is found it must be looked upon as a possible source of infection for cultivated plants. It was found that strains isolated from the sources mentioned, i.e. dandelion, black bryony, chestnut, and bramble, together with others from the flower heads of the African marigold, scabious and from pods of dwarf bean, when inoculated into apples induced a rot of the fruit visible within two days as a discoloration round the point of inoculation. The rot eventually extended over the whole fruit and many fructifications of *Botrytis cinerea* developed on the affected areas.

Such a wide range of host plants, involving so many sources of infection, makes the control of Grey Mould very difficult. *Botrytis cinerea* is so very sensitive to weather conditions, however, that serious damage by the fungus is to be feared only in very wet weather. It is most frequently found on plants, or parts of plants that are shaded and liable to have drops of moisture adhering to them for rather long periods, and one means of control therefore is to avoid overcrowding of plants and branches so as to allow free access of air and light. Those plants or parts of plants bearing Grey Mould should be collected carefully (so as not to scatter the spores unduly) and immediately burnt ; they should not be left lying about or the fungus will continue to develop on them and shed spores.

Where frequent loss is experienced from Grey Mould infection of fruit (particularly the occurrence of the dry eye rot referred to above, and of storage rot of apples) and of hop cones, attention should be given to eradicating weeds that are liable to harbour Grey Mould, and to keeping hedges, in the vicinity of fruit plantations and hop gardens, free from brambles and other plants that become attacked by Botrytis.

Infected hop cones should not be left to become shattered ; if they are not worth picking they should be cut down and burnt.

Summary.—An account is given of Grey Mould (*Botrytis cinerea* Pers.) on fruit and hops, with special reference to a Dry Eye Rot of apples. Grey Mould has been found on the dandelion, black bryony and brambles as well as on other hosts. Strains of *Botrytis cinerea* isolated from a number of host plants have been inoculated into apples and all readily produced rot. Measures of control are outlined.

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ENTOMOLOGY

NOTES ON SOME INTERESTING INSECTS OBSERVED IN 1940

By A. M. MASSEE

1. Strawberry Rhynchites (*Rhynchites germanicus* Hb.).—The Strawberry Rhynchites is frequently present in small numbers in Kentish strawberry fields during the latter part of April and May, but as a rule it does not cause much injury to the plants, and is not regarded as a serious pest. In 1940, however, several bad attacks were noted in various parts of Kent. Several outbreaks were noted in the Sutton Valence district, and one proved to be very severe, causing very considerable injury to maiden Royal Sovereign plants. Two- and three-year-old plants growing in adjoining fields were also damaged.

The weevil injures the plants by girdling the stalks of the fruit trusses and the stems of the leaves. The stems are frequently cut only half through, causing the leaves to flag and eventually dry up.

The weevil deposits one egg in the leaf petiole or in the stalk of the fruit truss, in the month of May, the date varying according to weather conditions. Having laid the egg, the weevil cuts off the shoot just below where the egg is deposited. The weevil seems to prefer maiden and two-year-old plants, but it does occasionally infest older plants also. It has the habit also of working right along a row of plants, cutting the stems of the leaves and fruit trusses as it goes along, and when not actually at work it hides in the soil.

An acre of maiden plants at Sutton Valence was almost completely defoliated by this stem-cutting weevil. Two other strawberry fields on the same holding were also attacked to a lesser degree.

An application of derris dust tends to check the ravages caused by Strawberry Rhynchites, but the dust must be applied directly the attack begins at the end of April or early in May. When the infestation is very severe, as it proved to be at Sutton Valence, a second application of dust may be necessary, especially in a rainy season.

At least three species of weevil contained in the genus *Rhynchites* cause very similar damage to the strawberry plant, but the only species noted at Sutton Valence proved to be *Rhynchites germanicus* Hb.

2. Shot Hole Borer (*Anisandrus dispar* F.).—The Shot Hole Borer is causing considerable damage to newly planted plum trees in several parts of Kent, notably in the Maidstone and Marden districts. It seems likely that one grower in the Marden area must have imported the Shot Hole Borer from the nursery where the trees were purchased, since the beetles were well-established in two year old " feathered " standard trees, some of which had been killed by the insect.

The adult female beetles emerge from their galleries within the stems in April and May, and may be seen resting on the trunks of the trees. Thus it is essential to examine the trees by the end of March at the latest, and to remove and burn those showing definite indication of attack.

The male Shot Hole beetle is regarded as very uncommon, and it is not represented in many collections. In point of fact it is by no means uncommon, but it is rarely seen since it does not come out of the galleries to the same extent as the female. It should be sought in the late autumn and winter months in the tunnels made by the beetle grubs.

In the writer's experience the proportion of females to males is about six to one. The female is shiny black and cylindrical, measuring one-eighth inch in length. The male is also black, but it is much smaller than the female, and is globular. In fact it might be readily mistaken for some other species.

3. Hop Strig Maggot. (*Contarinia humuli* Tölg). Although the Hop Strig Maggot has been present in a few hop gardens for very many years, it has not been regarded as a serious pest, and in consequence it has passed unnoticed by most hop growers.

It has been increasing steadily in the past few years, and in some districts it must be regarded as an important pest. Bad infestations have been noted at East Malling, Matfield, Paddock Wood, Penshurst, Tonbridge, Tenterden, and at Wingham, near Canterbury. It is also more prevalent in the hop-growing districts of Worcestershire and Hampshire.

A study of the life-cycle of the midge is being made in various hop gardens, and the adult midges were first noted on the wing in a hop garden at Paddock Wood on 23rd July. The peak period of the flight of the midge seems to be about the middle of August, and at that time large numbers may be observed flying about the garden when warm, sunny, conditions prevail.

Control measures are also being investigated, but it is proposed to repeat the initial experiments before reporting upon them.

4. Black Currant Midge (*Dasyneura tetensi* Rübs.).—The Black Currant Midge is also increasing in numbers, and may now be found in most parts of Kent where black currants are grown. It is curious that two closely allied midges—the hop species and the black currant species—should both be regarded as important pests in the last year or so, whereas a few years ago neither of them had been heard of by most fruitgrowers.

The Black Currant Midge causes most damage in the nursery, especially to newly planted black currant cuttings. The fact that the maggots confine their activities to the growing points of the shoots frequently renders young plants in the nursery row quite unsaleable. An example of this type of damage was noted at Southfleet during the second week in May, in which each bush in the nursery bed was severely damaged. The grower states that this is the first time the midge has been noted in the district.

5. Apple Capsid Bug. (*Plesiocoris rugicollis* Fall.).—Although many Kent fruitgrowers realize the importance of the Apple Capsid Bug, it is not generally recognized that this insect must be regarded as the most important apple pest of this country. In recent years it has spread through most of the fruit-growing districts of the county. Indeed it is now well established on the isolated apple trees in the garden, on the small holding, as well as the large fruit-growing areas of Kent.

It is still of considerable interest to note that it has not yet established itself at Headcorn, Sutton Valence, Goudhurst and Tenterden, but it is beginning to penetrate these areas, and doubtless it will spread throughout the country before long.

Now in order to obtain a commercial control of this pest throughout the country, it seems reasonable to suggest that every grower (whether he grows apples on a large scale or small) must follow certain well-known principles in order to rid his apple trees of this important pest.

In the first place it will be necessary, in many instances, to regulate the trees by " dehorning "

and the removal of branches, thus making possible the proper application of a petroleum spray which should follow in the early spring. With regard to the application of a petroleum spray (applied at a strength of $7\frac{1}{2}$ per cent.) it cannot be emphasized too strongly that a good, reliable and powerful machine is necessary for the work, one capable of producing a nozzle pressure of from 300 to 400 lb. per sq. inch. A less powerful machine, used in a standard apple orchard, particularly on a windy day, will prove quite inadequate. The necessity of a good agitator in the tank of the machine must also be stressed, since it is very important to emulsify the petroleum spray adequately.

Authorities differ as to the time of application of a petroleum spray, but a commercial control will be obtained if the spray is applied sometime during the last two weeks of March. It is not possible to give an exact date because of varying seasons, but the spray should be delayed until the bud is beginning to "move".

If apple Capsid is noted in the orchard after the time for applying a petroleum spray has passed, then a supplementary measure of control can be recommended. Namely, the application of a nicotine spray (Nicotine, 10 oz.; Spreader, 6 oz.; Water, 100 galls.) in the "pink-bud" stage. It should be noted that a nicotine spray is very much more effective against the Apple Capsid Bug if applied on a still, warm, sunny day, and such a day should be selected if conditions allow.

Prior to the application of the nicotine spray the trunks of the trees should be banded with a thin, narrow ring of grease-banding material. The object of the ring of grease will be readily understood. Directly the trees are sprayed with the nicotine, many of the young capsids, which at this period are very active and run rapidly, fall to the ground. At this stage they do not possess wings, and try to regain the tree again by way of the trunk, and in doing so many of them are caught in the grease.

6. Absence of Strawberry Aphis and Rubus Aphides in 1940.—Although very prolonged periods of cold and frost, such as those experienced in the winter of 1939-40 do not destroy many kinds of insect life—a fact long known to the Zoologist—there are as usual certain exceptions; and two of the exceptions concern species of aphides associated with soft fruits.

The best example is the Strawberry Aphis. This insect normally spends the winter in the wingless female form, attached to the under surfaces of the older leaves. In the autumn of 1939 the strawberry aphis proved to be abundant in commercial strawberry fields in the Maidstone district. A survey in December showed that the aphis was still plentiful. A further examination of the plants was made in January when most of the snow had melted, and this indicated that the aphis population had diminished considerably, but living specimens were still present after careful searching.

Further spells of bitter weather were experienced, and the fact that the plants were not protected by a covering of snow proved too much for the aphis. Indeed only one living specimen could be found after a search lasting three hours. Similar observations were made in many other strawberry fields in the Maidstone area and elsewhere.

The marked scarcity of the aphis continued throughout the spring, summer and early autumn, but by the end of the autumn the aphis population was normal.

A very similar story may be told of the four aphides which infest cultivated Rubi, including raspberry. The blackberry, loganberry and raspberry aphides were all abundant in 1939 and caused considerable damage in some districts. In 1940, however, they were markedly scarce, and when specimens were required for experimental purposes it was very difficult to obtain an adequate supply. Many forms of cultivated blackberry were severely damaged by the frost, and many varieties did not recover during the following season. It is impossible, therefore, that the condition of the plants may have accounted for the absence of the aphides.

The scarcity of the raspberry aphis is somewhat more puzzling. The raspberry canes were not affected by the frost to the same extent as the other forms of Rubi, and yet the aphis did not occur in the spring and summer months. A few, however, were found in one commercial plantation in the autumn months. The raspberry aphis overwinters in the egg state, and it seems possible that the egg must have been killed by the severe weather conditions. Yet this hypothesis would hardly agree with the known facts regarding the effect of cold weather upon the viability of the eggs of insects.

7. Hop Frog Hopper (*Evacanthus interruptus* L.).—An unusual infestation of the Hop Frog Hopper, or Hop Frog Fly occurred in a hop garden near East Malling. The immature hoppers first appeared in May and were very numerous. At first they confined themselves to feeding on the lower leaves, but later in the season they attacked the growing points of the bines and stunted the growths.

The young nymph is greenish, but the later stages are paler and marked with black lines. The adult is bright yellow, marked with two black longitudinal lines on the forewings. The adult is a very active insect, and flies readily on being disturbed.

There is only one generation in a year, and the hopper overwinters in the egg state. The eggs are laid in the cracks of the poles in August, but it does not necessarily follow that some are not in other situations as well.

The damage caused to the bine is quite characteristic, but so far they have not been seen damaging

the cones. Both the nymphs and adults feed on the undersurfaces of the leaves and also on the bines, usually near the tips. Their continuous feeding causes the leaves to split and many become malformed. When the shoot is attacked it becomes distorted and the growth is checked. When the infestation is severe, as was the case in the garden near East Malling, the leaves turn pale yellow, and the bine may be partly defoliated. In addition the growth is affected in a manner aptly described by the late Professor Theobald thus : " the leading shoots cease to spiral and the leaves curl up ; the bine is also punctured and the growth arrested ".

The Hop Frog Hopper is a common British insect which feeds upon many kinds of weeds and cultivated plants, in addition to the hop. It is difficult to understand why such a common insect is not more prevalent in the hop gardens of Kent. It occurs commonly on the wild plants growing in the hedgerows adjoining the Research Station hop gardens, and yet it does not attack the hops adjoining. It also occurs commonly on the wild plants on the headland of two other hop gardens in the East Malling district, but it does not occur on the hops growing near at hand.

No attempt has been made to control the Hop Frog Hopper in the field experimentally, but it has been observed that the number of hoppers was greatly reduced in a garden receiving two applications of a derris dust in July. The dust was actually applied to control the Hop Red Spider, and was not used with a view to controlling the Hop Frog Hopper.

8. Apple Leaf Hopper (*Typhlocyba froggatti* Baker).—The leaf hoppers associated with cultivated fruits have been very much neglected in this country until recently, when a start was made to determine the British species and to study their life-cycles. One result of this investigation shows that eleven species of leaf hoppers actually breed on apple, and there is reason to believe that more species will be found on this host as the work proceeds. Of the eleven species, one may prove to be of considerable economic importance, and will be referred to in some detail.

In the late spring and summer months of 1940 unusually large numbers of leaf hoppers were noted swarming on apple and other fruits in many orchards in the Maidstone district. Large numbers of these hoppers were collected from various orchards with the object of determining the species. The predominant species proved to be *Typhlocyba froggatti* Baker, an insect hitherto only recorded as British as the result of the capture of a single specimen on hawthorn in Scotland last year. It seems likely, however, that *T. froggatti* has been present in this country for many years, since the presence of tens of thousands in the Maidstone district must have been the result of steady breeding for a number of seasons. It is more probable that in the past the species has been confused with the rose hopper (*T. rosae* L.) which is almost identical in general appearance.

T. froggatti was first recorded in Australia by Froggatt in 1918, a well-known economic entomologist of that country. It also occurs in Tasmania and New Zealand. It is regarded as a pest of considerable importance in the apple growing districts of these three countries.

The life-cycle of the Apple Leaf Hopper has not been studied in detail in this country, but a few observations have been made. Two generations have been noted in a season, and the insect hibernates in the egg state within the tissue of the young shoots and branches. It has many host plants in addition to apple, including pear, plum, cherry, quince and hawthorn.

A second species of leaf hopper, *T. quercus* (F.) is found on apple in association with *T. froggatti* but it is much less common. *T. quercus* may be recognized at a glance from all other fruit species by the red markings on the forewings. Unlike the common apple species it hibernates in the adult state amongst dead leaves and in the foliage of evergreens. The natural host plant of this species is the oak.

9. Plum Leaf Hopper (*Eupteryx stellulata* Burm.).—This very beautiful leaf hopper is abundant on plum and cherry, and yet it does not appear to have been recorded on fruit previously in this country. It is, however, well known on the Continent, and it is common in France.

The forewings are creamy-white, the veins and the tips of the wings being dark brown. The pattern and colourings of the wings are very handsome, and readily distinguish the species from the other nineteen species found on plum.

This species is very abundant on plum and cherry at Southfleet, and it is locally common in the Maidstone district. It is also common in many parts of Kent on oak and lime.

E. stellulata is not yet regarded as an economic species in this country, but since it is becoming more common on fruit of late years it seems worthy of notice.

10. Cuckoo Spit Insect (*Cercopis sanguinea* Geoff.).—The Cuckoo Spit Insect or Frog Hopper, as it is sometimes named, is also a very handsome insect. The forewings are checkered with conspicuous red and black markings, and it is three-eighths of an inch long. Under natural conditions the adult flies very readily on sunny days in May and June. In cloudy weather it may be seen resting on the leaves and stems of various trees, shrubs and low plants. The immature stages are pale yellow and are completely enveloped in " spittle ". They are said to be associated with the roots of dock, which is considered their natural food plant.

The Cuckoo Spit Insect is of considerable interest to growers because the adult insects have been reported damaging apples and pears in a mixed fruit plantation at Tenterden, Kent, during the past three seasons. The orchard was visited on 27th May and large numbers of adult Cuckoo Spit Insects were noted feeding on the foliage of apples and the fruits of pear. They were very active and difficult to catch on account of their jumping powers, and flew away immediately on being approached. An examination of the attacked leaves indicated that the insects had been feeding on them for some time.

The injury caused by these sucking insects is very characteristic. On apple the feeding is confined to the leaves. At first the markings are greenish-yellow, but later turn brown. They are angular in shape and may be very numerous, frequently numbering two to three hundred on a single, leaf. These leaf markings are equally conspicuous on both surfaces. The adult also infests pear but on this host the feeding is confined to the fruitlets and the stalks. The adults feed on the fruitlets causing rough, corky patches and blisters, and, in extreme cases, the splitting of the fruits. The stalks are often attacked causing them to become scarred and twisted, resulting in malformed fruits.

The grower states that he has noticed similar damage for several years, and that in 1939 it was first seen on 27th May. He states also that the injury to the pear fruits during the past three seasons has been so serious that it has not been possible to market the crop, and it is proposed to grub the pear trees.

Similar markings on apple leaves have been described by several observers under the popular name of Angular Leaf Spot, and the damage was at first attributed to a fungus that was found on the spots. It is now agreed, however, that *Cercopis sanguinea* is the primary cause and that the fungus is a saprophyte on the dead spots.

11. Black Currant Eelworm (*Aphelenchoides ribes* (Taylor) Goodey).—The Black Currant Eelworm is an uncommon species which sometimes causes damage to the variety, Daniel's September Black. It is rarely found on other varieties. It is therefore of interest to report a bad infestation on the variety, Westwick Choice, near Bognor, West Sussex. A number of attacked shoots were examined in April and they showed typical symptoms of the disease. The attacked buds remain dormant, they are a little shrivelled, and many of the buds are killed. All the buds on some of the shoots examined were " blind ", but a few of them produced weak leaves when placed in a jar containing sand and water. The grower states that other varieties in the near vicinity are not affected.

Summary.—Notes are given on some interesting insect pests of fruit trees and hops observed during 1940.

STRAWBERRY APHIS AND THE WEATHER IN 1940

By R. M. GREENSLADE

THE scarcity of Strawberry Aphis, *Capitophorus fragariae* Theob., in 1940 was undoubtedly due to the very severe weather during the early part of the year, and the following notes show how the aphis population at East Malling was reduced almost to nothing.

On 29th September, 1939 a survey of the aphis population was made in a 4-acre field of strawberries at East Malling Research Station. The survey was made by the method described by Greenslade and Pearce (1940) and the index figure then was 2·79. A fairly high population was maintained during October and November and into the first part of December. At the end of December snow fell and the plants were covered to a depth of two or three inches for a month, during which time the ground temperature fell to – 5° F. On 28th January a search was made for Capitophorus under the snow and 39 were found in a short time, but only two were alive. On 3rd February there was a rapid thaw and by the 10th nearly all snow had gone, but on the 14th there was a further heavy fall. Yet another fall, covering the plant, occurred on the 14th March. On the 12th March another search was made but 500 plants were examined before an aphis was discovered. Evidently the population had been very much reduced by the severe weather, and in fact Strawberry Aphis seemed to be almost non-existent in the spring of 1940, not only in the field in question but throughout Kent. During the summer the field was kept under observation and in June aphides were noticed again in very small numbers though no winged forms were seen. A survey was made on 11th July and from then on the aphis population increased as shown by the following surveys :

11/7/40.	Population index	..	..	1·01
4/9/40.	,, ,,	..	..	2·60
28/10/40.	,, ,,	..	..	2·82
28/11/40	,, ,,	..	..	1·31

Judging from the figures obtained during the work on sampling previously described (Greenslade and Pearce, 1940), the population had reached its normal level by September in spite of being almost nil in June when it should have been at the peak.

Another interesting point noticed during the surveys of 1940 was the re-infestation of a plot treated with vaporized nicotine. On 29th September, 1939, the day of the first survey mentioned above, an experiment on the control of Strawberry Aphis by vaporized nicotine was carried out in collaboration with Dr. Ripper, of Harston, Cambridge. About 3 acres of the 4-acre field in which the surveys were made was treated, the remainder being left as untreated check. The treatment gave practically 100 per cent. control (one aphis was found on 70 leaves on the following day). Aphides were not observed on this part of the field until early September, and on 30th October the population index was 1·64, at a time when the untreated part of the field was 2·82. Thirty-three of the 70 sample leaves picked had no aphides on them as against one only without aphides in a similar sample from the untreated part of the field.

Now if the infinitesimal population left after the severe winter could return to normal level by September there seems no reason why that of the treated part should not also return to normal. It can only be assumed therefore that the aphis on the treated part was practically exterminated, perhaps by a combination of treatment and weather, and that the population present in October was the result of migration from the untreated plants alongside. In any case the effect of the treatment had persisted for a year in close proximity to a source of re-infection, and the aphis population of the treated plants was only just over a third of that of the untreated check. If there had been no source of re-infestation the aphis population of the treated plants would have been negligible.

Summary.—Observations and population counts have shown that the Strawberry Aphis, *Capitophorus fragariae* Theob., although nearly exterminated by the severe weather of January and February 1940, was just as numerous as usual by September. Similar observations showed that the effects of aphis control by vaporized nicotine persisted for a year even with full opportunity for re-infestation.

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THE BLACK CURRANT LEAF MIDGE

DASYNEURA TETENSI (RÜBS.)

By R. M. GREENSLADE

Introduction.—The Black Currant Leaf Midge, *Dasyneura tetensi* was first described, in Germany, by Rübsaamen (1891). It was first recorded in England by Bagnall and Harrison (1917) in Durham, and was first noted as a possible pest when it was recorded by Massee (1931) on damaged black currant shoots found in a nursery in Kent by Mr. J. Turnbull. Rübsaamen (1912) and Bagnall and Harrison (1917) record the species also from gooseberry, but Barnes (1931, 1939) carried out a series of experiments which showed that *D. tetensi* will not lay eggs on other species of Ribes or on blackberry. Further evidence of this was obtained at East Malling in 1940. An infested bush of *Ribes nigrum* stands in the middle of a small plot of 42 other species of Ribes on none of which could larvae be found. It seems probable, according to Barnes (1939) that *D. tetensi* is restricted to black currant and that the gooseberry midges are the allied species, *D. ribicola* Kieffer.

The experience of fruitgrowers and research workers seems to show that the Black Currant Leaf Midge has been growing more widespread especially in Kent, in the past few years (Massee, 1939) and, although it is still not certain whether serious damage is done to fully grown bushes, it has certainly become a pest in the nursery.

Life History.—The Black Currant Leaf Midge belongs to the same family of flies (*Cecidomyidae* or Gall Midges) as the Pear Midge (*Contarinia pyrivora*), the Pear Leaf-curling Midge (*Dasyneura pyri*) and the Hop Strig Maggot (*Contarinia humuli*) and lives in much the same way. The adult flies lay their eggs on the plant; the maggots live and feed on the plant causing a deformation of the leaves which can hardly be considered a true gall, and when mature they fall to the ground and pupate in

the soil. The insect spends the autumn and winter in the soil as a pupa or possibly as a "resting" larva.

The eggs are cigar-shaped (sometimes tapering slightly to one end) and measure 0·27 mm. × 0·07 mm. being therefore scarcely visible to the naked eye. They are whitish and the developing embryo can be seen within. They are laid on very young leaves at the tip of growing shoots of black currant, on either surface of the leaf, but always between the folds where they are protected from drying.

The larvae also need protection within the folds of the leaf. The injury caused by their feeding on the upper surface of the leaf prevents it from growing as fast as the lower surface. The leaf continues to grow but always remains folded and crumpled. (Fig. 2.) The shoots chosen for egg laying are growing so fast that the presence of the maggots can be detected by the deformation of the leaf (Fig. 3) within a day of hatching. As many as 14 larvae have been found in a leaf, but the usual number is 4 or 5. Larvae reared on a pot plant of black currant matured and pupated in 10 to 12 days, but field observations, as will be shown later, suggest that some may take a shorter or longer time than this. On pot plants in the laboratory the larvae nearly always became orange-coloured before leaving the leaf to pupate, but this coloration was not noted in the field, although several thousand mature white larvae were seen in the course of observations throughout the summer. A similar phenomenon in other Cecidomyid larvae is mentioned by Kieffer (1900). When mature the larva falls to the ground and works its way into the soil where it pupates at a depth of two or three inches.

The pupa is formed in a silken cocoon several inches below the surface of the soil. The cocoon is normally fairly tough, but some formed in the laboratory in sand were extremely flimsy. In the field they are extremely difficult to find.

The adults are very active and fly readily in still weather, but when there is any wind they remain at the base of the bushes on the lower parts of the stems and among dead leaves on the ground. They are only about one-sixteenth of an inch long and without microscopical examination they are not distinguishable from other species of Cecidomyid flies found in the same situation. They are often caught in spiders' webs at the base of the bushes but, in common with the other species found there, they have the power of landing deliberately on the web without being trapped. This habit of Cecidomyid flies is also mentioned by Kieffer (1900, p. 258).

Number of broods.—Rübsaamen (1891) noted that there were several generations in the course of a year. Barnes (1939) stated that there were three, the adults appearing in April, May and early June, in late May and June, and in late July and August. In 1940 at East Malling there were four broods of which the last may have been incomplete as will be explained later. As the adults are

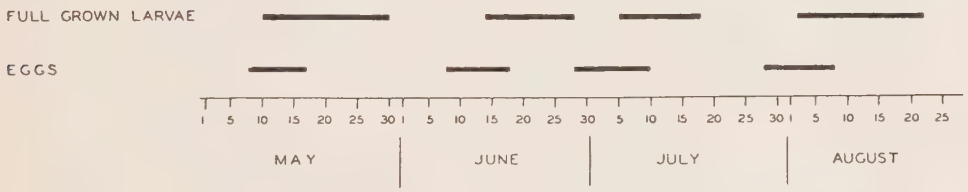

FIG. 1.

Generations of *Dasyneura tetensi* in 1940.

sometimes difficult to find, the number of broods was determined by noting the presence of eggs and of full grown larvae in samples of leaves collected every two days, and sometimes every day, during the breeding season. Fig. 1 shows the periods when eggs and full grown larvae were present in the shoots. It will be seen that there were four generations, the adults appearing in early May, mid June, early July and early August. The presence of full grown larvae is the safest method of determining the number of broods, especially when they follow one another quickly, as eggs are more likely to be overlooked, particularly at the beginning of a generation, unless very large samples of leaves can be examined. The presence of eggs, on the other hand, gives a better indication of the duration of the adult flight period which was approximately 10 days to 2 weeks. Fig. 1 also shows that there was some variation in the development period of the larvae, since the first full grown larva was usually found about six days after the first eggs, but the last full grown larvae were in the shoots as much as 14 days after the last eggs were found. The short period between the first eggs and full grown larvae in May was probably due to inexperience in finding the eggs at that time.

The fourth generation of larvae apparently does not always occur. At East Malling in August, during very dry weather, the currants ceased to produce new leaves with the exception of the variety Goliath and certain seedlings mentioned later. A fourth generation of larvae appeared on these, but in another widely separated plot containing none of these varieties there was no sign of larvae. It seems probable that some adults of the fourth generation emerge and lay their eggs if they find suitable shoots. But if the species is to persist, as it does, in plantations of other varieties, then some of the third brood pupae must remain in the soil and give rise to the first brood of adults in the following year. The first generation of larvae of the year would then be a mixture of the offspring of the third and fourth generations of the previous year. Arrangements will be made to determine whether midges emerge in 1941 from the soil under bushes known to have harboured no fourth generation in 1940.

Migration.—During 1940 some cuttings planted the previous winter became infested, presumably by the migration of adult flies from the nearest currant plot, a distance of 500 yards.

Injury to the host plant.—The injury to the host plant consists of malformation and crumpling of the leaves at the tips of shoots. In the very early stage the young unfolding leaf twists over to one side in a characteristic manner (Fig. 3). There is no undue forking of the shoots, but the growing tip is stunted and often loses its leaves. The fruit crop is apparently not affected on established bushes and certainly receives no direct injury from the maggots.

In the nursery the midge may be a very serious pest, preventing cuttings from growing and rendering thousands of potential bushes unsaleable. There has been at least one case of a nurseryman being forced to give up raising black currants on part of his land because of the damage caused by Black Currant Leaf Midge, and several nurseries in Kent have been seriously troubled by this pest. When the leaves have opened, that is after the larvae have gone, the injury may at first sight be confused with that of the Green Capsid Bug (*Lygus pabulinus*). Closer examination shows that the surface has actually been eaten, and the injury is soon easily distinguished from that of *Lygus*.

Varietal susceptibility of Black Currants.—As mentioned above, the Black Currant Leaf Midge does not infest Red Currants or other species of Ribes, but in the course of field observations in 1940 it became evident that there were differences in susceptibility between different varieties of the Black Currant. Fortunately it was possible to demonstrate these differences. A field cropping trial of Black Currant varieties was available for sampling. This contained the four varieties: Seabrook's Black, Baldwin, Boskoop Giant and Goliath, laid out in a 4 by 4 Latin square of 120 bushes in each block. Twenty bushes were selected spaced at intervals along each block, and from each of these bushes 10 shoots, chosen at random, were examined for damage. In all 800 shoots of each variety were examined and the number of damaged shoots recorded. Four other varieties. Davison's Eight and Wellington Single X, Double X and Triple X, were planted alongside this trial and could fairly be compared with it. Two hundred shoots of each of these varieties were examined. The following results were obtained:

Varietal Susceptibility of Black Currants to *Dasyneura tetensi*.

Variety.	Percentage of shoots damaged.
Davison's Eight	24·0
Boskoop Giant	26·0
Double X	33·5
Single X	38·0
Triple X	38·0
Baldwin	39·4
Seabrook's Black	40·5
Goliath	59·4

These figures suggest that there may be a range of susceptibility in the varieties named, but the first seven do not differ significantly from one another. Goliath however, is far more susceptible than any of the others. Goliath differs most obviously from the other varieties in the relatively high number of terminal shoots and in the fact that it continues to make new leaves all through the summer at a time when other varieties have ceased to grow. This was very noticeable in 1940 when dry weather in late summer checked the growth of all varieties except Goliath. Subsequent rain brought on new growth in all varieties, but in October, when the leaves began to fall, Goliath still had young leaves. This was so marked that the blocks of Goliath in the trial mentioned above

FIG. 2.
Injury to Black Currant leaves caused by larvae of Black Currant Leaf Midge.

FIG. 3.
Injury caused to Black Currant leaves by Black Currant Leaf Midge—earliest stage.
Note characteristic twisting of youngest leaf.

could be picked out at a glance after all the leaves had fallen from the rest of the plot. The midge needs young unexpanded leaves for egg laying and the continued presence of such leaves on Goliath would be sufficient to explain the susceptibility of this variety. It should be noted that in sampling, the percentage of damaged shoots was recorded, not merely of shoots infected at the moment of sampling.

Another sample of shoots was examined on a plot of Black Currant seedlings laid down for cropping trials and not yet in commercial use. Boskoop Giant and Baldwin were planted with this trial but unfortunately not Goliath. The samples showed the following differences.

Variety.	Percentage of shoots damaged.
Boskoop Giant	21·9
Seedling H.T.7 (Boskoop × Baldwin × Boskoop)	31·6
Baldwin	32·6
Seedling H.T.6 (Baldwin × Goliath × Baldwin)	37·9
Seedling H.T.3 (Goliath × Baldwin)	40·0
Seedling H.T.5 (Baldwin × Goliath × Baldwin)	44·0
Seedling H.T.2 (Goliath × Baldwin)	46·6
Seedling H.T.4 (Emsden's Defiance selfed)	55·1

Sig. diff. (P = ·05) 7·8

It is interesting to note that Goliath appears to have passed on its susceptibility to the seedlings in which it was used as a parent and also that a seedling containing Boskoop shows a low susceptibility.

Effect of wind on infestation.—The adult Black Currant Leaf Midges are so small and delicate that it was obvious they would be seriously hampered in flight by any wind above the lightest breeze. This was found to be so, and was well illustrated by observations made on two plots, each of four acres, at East Malling Research Station in 1940. In May the maggots in the former plot, which is in a very exposed situation, were confined to the tips of the young new shoots coming up from the base of the bushes, that is, within a foot of the ground. The currants in the other plot were interplanted among half-standard plums and cherries and had tall wind-breaks on all sides. Here the infested shoots were found on all parts of the bushes in May. Later, in July and August, after spells of quiet weather, flies were able to reach all parts of the bushes on both plots and no further difference in type of infestation could be seen.

Effect of soil on infestation.—In the plot showing differences in varietal susceptibility there was also a marked soil effect. The plot was laid out in such a way that the soil differences could not influence the varietal differences mentioned above. Dividing the plot into four equal strips running from east to west the following per cent. infested shoots were noted :

(1) 42·5. (2) 52·4. (3) 36·5. (4) 33·6.

The infestation was noticeably and measurably higher in the second strip. The growth of the bushes in this strip, containing one block of each variety, was much more vigorous than elsewhere on the plot, and it is possible that this provided extra shelter against the wind and therefore harboured more midges than the rest of the plot.

Control Measures.—The efficient application of control measures against a many-brooded insect such as the Black Currant Leaf Midge, requires careful timing, since a method useful against one stage of the insect may fail entirely through being used when the insect was present in more than one stage. Experimental work on its control is complicated by the ability of the adult flies to migrate from plot to plot, making it necessary to use widely separated plots for each treatment and to apply each treatment to a whole plot, however large. As already noted they can migrate at least 500 yards.

With this species there are three stages against which control measures may be directed, the eggs and larvae, the pupae and the adult flies. Control through the pupal stage may be considered as almost impossible. Chemical treatment of the soil would be uneconomic and of doubtful efficacy, and owing to the shallow rooting habit of the black currant, any drastic manipulation of the soil immediately under the bushes would be most undesirable. Attention was therefore given to the other two stages only.

Spraying experiments were carried out in May, 1940, against the larvae. Nicotine was used at 10 oz. and 20 oz. per 100 gallons, with 5 lb. soft soap. These sprays were very thoroughly applied to 11 bushes each, but not a single dead larva could be found, either on the bushes or on the ground.

Fumigation with nicotine vapour was next tried. On 14th May, 15th May and 21st May, a number of bushes were fumigated by covering closely with a sheet and vaporizing nicotine from a

shallow pan by means of a paraffin lamp as used in greenhouse fumigation. Each time many dead larvae were found, both in the twisted leaves and on the hard baked ground under the bushes. It was difficult to build up a high concentration of nicotine and the distribution of vapour within the space under the sheet seemed rather irregular, but these difficulties could be overcome and further work must be carried out. Currants could easily be fumigated with nicotine on a field scale, and if a good control could be obtained this would be a valuable method.

The other method of control, that of killing the adult flies, was tried on 7th August, 1940. A dust containing 3 per cent. of nicotine was applied in hot, still weather. The dust was mainly directed into the base of the bushes, the chief resting place of the adult flies, and as it was the first trial of this method, a heavy dressing of 14 lb. on a quarter of an acre was given. After the dusting, no adult midges of this or other species could be found on the bushes, and the dust was evidently effective in killing them, but it was not realized at that time that some of the fourth generation may remain in the soil and emerge in the following spring. This means that a complete control would not be possible at that time of year. Control of the adult flies is obviously most applicable to the first generation since the midsummer generations probably overlap in many seasons and in any case dusts cannot be applied in the fruiting season. An insecticide for use against the adults must remain effective over several days as the adults fly for a period of 12-14 days. It is no use deferring treatment until all have hatched, since eggs would then be present. Possibly two applications of dust may be necessary during the flight period of one generation. Further work will be carried out in 1941.

Another possibility to be investigated is the use of a repellant to prevent the adults laying their eggs. This, if possible, would be a very useful method, since individual bushes would be protected even when neighbouring plantations remained heavily infected.

Acknowledgement.—The writer is indebted to Dr. H. F. Barnes, of Rothamsted Experimental Station for identification of midges.

Summary.—The Black Currant Leaf Midge, *Dasyneura tetensi* (Rübs.) is becoming more common and is of importance as a pest in the nursery. In 1940 four generations were observed, the adult flies being on the wing in May, June, July and August. It is probable that some of the flies of the last generation do not emerge until the following spring. The insect is confined to *Ribes nigrum*, but there are considerable differences in susceptibility between different varieties, the variety Goliath, being particularly susceptible. The adult flies appear to be much influenced by wind, since the sheltered parts of currant plantations are more heavily infested than those exposed to wind. Attempted control measures are described and methods for future trial, based on the knowledge acquired of the life history, are discussed.

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INSECTICIDES AND FUNGICIDES

DINITROCRESOL AND OTHER DUAL PURPOSE WINTER WASHES

By H. SHAW and W. STEER

THE introduction of tar-distillate and petroleum emulsions armed the fruit grower with powerful and effective weapons for the control of some of his most serious pests. It was to be expected that efforts would be made to combine the two types of oil satisfactorily in one preparation that would kill the eggs of aphides, Apple Sucker, Capsid Bugs, Red Spider and Winter Moth in one spraying. In this way the various tar-petroleum mixtures were evolved. Considerable quantities of these are still used, but they have never become very popular, partly because they need to be used at high concentrations and are apt to damage the buds. In recent years, consequently, attempts have been made to produce a more satisfactory "dual purpose" wash. So far the only practicable method has been the incorporation in a petroleum emulsion of some substance highly toxic to the eggs of aphides and sucker, insects normally controlled by a tar wash. The egg-killing properties of one such substance, 3 : 5-dinitro-*o*-cresol,* were discovered by Tattersfield *et al.* (1925), whose laboratory experiments were supplemented by a field trial carried out at East Malling in the winter of 1924-5 (Gimingham *et al.*, 1926). The results were promising and were confirmed in further field trials (Gimingham and Tattersfield, 1927; Tattersfield and Gimingham, 1928), but, as this work preceded the introduction of winter petroleum washes, and for various other reasons, the new ovicide was not fully exploited and so failed to compete with the tar distillates. In 1934 the question was reopened by the present writers and, almost simultaneously, by some manufacturers. Dinitrocresol was found to combine well with petroleum oils, and laboratory tests (Shaw and Steer, 1939) showed that as little as 0·05% (1 part in 2,000), made up in a sulphite-lye emulsion of a petroleum oil, was completely toxic to eggs of the Green Apple Aphis (*Aphis pomi*). Later tests have shown that the concentration can be reduced to 0·025% (1 in 4,000) and still remain effective under laboratory conditions.

TABLE I.

HATCH OF *A. pomi* EGGS.

Material tested.	Concentration %.	Hatch %.
1937.		
Lauryl thiocyanate	0·25	0
Lethane 410	0·25	0
Untreated	—	93·0
1938.		
Dinitrocresol (in 5% Grade E petroleum oil†)	0·05	0
,, (in 1% special petroleum oil‡)	0·05	0
Grade E petroleum oil alone	5·0	74·0
Special petroleum oil alone	1·0	65·7
Untreated	—	93·8
1939.		
Dinitrocresol (in 3% Grade E petroleum oil)	0·05	0
,, ,, ,, ,,	0·025	0
,, ,, ,, ,,	0·01	12·6
Lethane 410 ,, ,, ,,	0·2	0
,, ,, ,, ,,	0·1	0
,, ,, ,, ,,	0·05	42·1
Lauryl thiocyanate ,, ,,	0·2	7·2
,, ,, ,, ,,	0·1	34·1
Grade E petroleum oil alone	3·0	37·9
Untreated	—	78·7

* It will be convenient to refer to this material as "D.N.C.", by which name it is now commonly known.

† Martin (1935). ‡ An Edeleanu extract of high solvent power for dinitrocresol.

The potentialities of substances other than D.N.C. have also been investigated. Kearns and Martin (1936) considered D.N.C. unsuitable and, following up the work of Murphy and Peet (1933), incorporated organic thiocyanates with petroleum oil, obtaining good results against *A. pomi* eggs with 0·4% of lauryl thiocyanate. The present authors (1939) found another organic thiocyanate, β-butoxy-β′-thiocyanodiethylether* to be at least as toxic as lauryl thiocyanate to a variety of insect eggs, though Jary and Austin (1938) had found it less so to eggs of the Hop Red Spider (*Tetranychus telarius*).

Tables I-III indicate results that have been obtained in laboratory trials.

TABLE II.

PER CENT. HATCH OF WINTER MOTH (*Operophtera brumata*) EGGS.

1938.

Concentration %.	Sodium Dinitrocresylate.	Lethane 410.	Lauryl thiocyanate.
0·4	—	71·3	46·8
0·25	33·2	—	—
0·2	45·8	84·2	74·5
0·15	35·8	—	—
0·1	56·0	—	—
Untreated		91·1	

1939.

Concentration %.	Dinitrocresol.*	Sodium Dinitrocresylate.	Lethane 410.	Lauryl thiocyanate.
0·5	—	—	43·2	40·5
0·25	58·2	28·8	71·7	73·6
Untreated			89·7	

* In a sulphite-lye emulsion of 5% benzene which itself was not toxic (92·6% hatch). All other preparations were in 1% soap solution.

TABLE III.

HATCH OF RED SPIDER (*Oligonychus ulmi*) EGGS.

Material tested.	Concentration %.	Hatch %.
Dinitrocresol (in 1% special petroleum oil)	0·1	0·9
Lethane 410 ,, ,, ,,	0·1	29·9
Special petroleum oil alone	2·0	60·0
Untreated	—	86·0

Field trials with D.N.C. and the two thiocyanates have confirmed the laboratory findings. The effect of these materials on the eggs of plum aphides (*Anuraphis padi* and *Phorodon humuli*) has already been reported upon (Shaw and Steer, 1939). A trial on apple trees showed that 0·05% of D.N.C. in a sulphite-lye emulsion of petroleum oil gave a satisfactory control of Apple Sucker (*Psyllia mali*) and of Rosy Aphis (*Anuraphis roseus*). A still lower concentration (0·025%) controlled the aphis, but did not eliminate the sucker. Lethane 410, at 0·1% in a similar medium, did not give an entirely satisfactory control of aphis or sucker, and compared unfavourably in this respect with a soap-emulsified tar wash containing 2% of neutral oil. The results are given in Table IV. The indifferent

* Used in the form of Lethane 410 and referred to hereafter as such. This material contains 75% of the thiocyanate and 25% of kerosene.

TABLE IV.

EFFECT OF VARIOUS WASHES APPLIED TO BRAMLEY'S SEEDLING APPLE TREES* ON MARCH 4TH AND 5TH, 1940.

Treatment.	Control of		
	Aphis.	Sucker.	Caterpillar.
5% Grade E petroleum oil	poor—moderate	poor	moderate
,, ,, ,, +0·05% D.N.C.	good	good	moderate
,, ,, ,, +0·0125% ,, ...	good	moderate	poor
,, ,, ,, +0·1% Lethane 410	moderate	moderate	moderate
2·8% Strained anthracene oil (=2·5% neutral oil)	good	good	moderate
2·25% ,, ,, ,, (=2·0% ,, ,,)	moderate—good	good	moderate
Unsprayed	poor	poor	poor

* The authors are indebted to Mr. H. Brown of Detling, Kent, for the use of his orchard.

control of caterpillar was due to a severe attack by Tortrix Moth caterpillars ; this made it impossible to assess the value of the several washes against Winter Moth (*Operophtera brumata*).

Several proprietary forms of the D.N.C.-petroleum oil wash and at least one preparation of β-butoxy-β′-thiocyanodiethylether are now available. Field trials with some of these have been reported upon by Hey (1938) and by Hardy (1940).

The search for alternative ingredients of dual purpose washes continues and among substances being tested at East Malling are several dinitrophenols and other related dinitro compounds. Of these, all that can be said at present is that none of them appears to be superior to D.N.C., though some deserve further study.

In our experiments D.N.C. has proved more effective, weight for weight, than any thiocyanate, nitrophenol, or other organic substance tested, and it has now stood the test of commercial trial. Before the present war all the dinitrocresol used in proprietary washes was of foreign origin. In consequence, supplies were cut off for a time, but are now available from British sources, and so the continued production of this type of wash seems to be assured.

It is pertinent to enquire whether D.N.C., in addition to controlling aphides and sucker, contributes anything to the control of the pests for which the petroleum oil itself is intended. In the case of caterpillar the concentration of cresol used is too low to have much effect (Table II). Against the eggs of Red Spider (*Oligonychus ulmi*) 0·1% of D.N.C. was found very toxic in the laboratory (Shaw and Steer, 1939), but the amount of Grade E petroleum oil necessary to act as a medium for such a concentration is itself more than sufficient to kill the eggs. The same, perhaps, is true of Apple Capsid (*Plesiocoris rugicollis*). A very small-scale trial in 1939 showed that the addition of 0·05% D.N.C. did not detract from, and may have improved, the performance of a 3% oil emulsion applied on 31st March. It would be well, however, not to expect the D.N.C. ingredient of a dual purpose wash to do more than a tar distillate will, and to use the wash at a concentration that contains sufficient oil to control capsid. Recent trial has shown (Steer and Moore, 1941) that less than 6% of actual oil is insufficient to kill the eggs of Apple Capsid unless spraying is deferred till late March or early April, when 5% of oil is sufficient. As D.N.C. washes must, to avoid scorch, be used not later than mid-March, it is advisable to employ them at concentrations yielding not less than 6% of oil. With washes of declared composition the appropriate concentration can readily be calculated.

Just as occasionally batches of tar and petroleum washes may be defective, some samples of D.N.C. wash may break down on prolonged standing. Growers should, therefore, take steps to satisfy themselves that their stock is sound before using it ; a good wash should be a homogeneous, creamy, bright yellow emulsion. For D.N.C. washes there is the same need for very thorough spraying as applies to " straight " petroleum emulsions. The same care, too, must be taken to avoid spraying in windy weather.

One spraying of D.N.C. wash is much cheaper than the separate spraying of tar oil and petroleum oil, even if the petroleum is applied at the reduced concentration that may be used when the spraying is carried out late in March or early in April. For quantities of ten or more drums of the several types of winter wash, the prices ruling at the close of the 1940-41 season, per barrel of 40 gallons and subject to the usual 5% discount, were as follows :

Standard tar oil wash	£4 10s. 6d.	per barrel of 40 gallons.
Petroleum oil wash	£5 7s. 6d.	,, ,,
Tar-petroleum mixture	£5 7s. 6d.	,, ,,
D.N.C.-oil mixture	£5 17s. 6d.	,, ,,
Thiocyanate-oil mixture	£9 2s. 0d.	,, ,,

Assuming for purposes of comparison a consumption of 400 gallons, the net costs per acre of appropriate concentrations of the various spray materials are :

Double spraying.

(1) 5% tar oil wash ..	£2	3s.	0d.	(2) 5% tar oil wash ..	£2	3s.	0d.
$7\frac{1}{2}$% petroleum wash ..	£3	16s.	8d.	$6\frac{1}{4}$% petroleum wash ..	£3	3s.	10d.
	£5	19s.	8d.		£5	6s.	10d.

Single spraying.

(3) 10% tar-petroleum mixture	£5	2s.	2d.	(4) 8% D.N.C. wash ..	£4	9s.	4d.

In the absence of information as to its content of oil and of thiocyanate, the thiocyanate-oil type of wash has been omitted from the above comparison. It would need to be used at less than $5\frac{1}{2}$% to compete in cost with 8% of a D.N.C. wash, but, if effective at low concentrations, it may prove useful in certain circumstances. It can be used much later than a D.N.C. wash, as late in fact as any " straight " petroleum. It can be used, too, where vegetables or other susceptible undercrops preclude the use of either a tar or D.N.C. wash.

The saving on the cost of application (water, labour, fuel, wear and tear, etc.) has not been taken into account as it would vary with differing circumstances and would be partly offset by a somewhat heavier consumption of dual purpose wash as compared with petroleum following tar oil.

Summary.—Field and laboratory trials have shown that 3 : 5-dinitro-*o*-cresol can be relied upon to control the eggs of plum and apple aphides and Apple Sucker when used at a concentration of 0·05% in a Grade E type of petroleum oil.

β-butoxy-β′-thiocyanodiethylether (as Lethane 410) and lauryl thiocyanate were each less toxic to the eggs of any of the pests against which they were tested, though the first of these is, at 0·1%, a satisfactory constituent of a dual purpose wash.

None of them was sufficiently toxic to Winter Moth eggs to contribute much to the control of caterpillar given by a winter petroleum wash. At 0·1% dinitrocresol was more toxic than Lethane 410 to Red Spider eggs, but the amount of oil likely to be used with such a concentration is itself sufficiently toxic.

D.N.C. washes are favoured for use late in the dormant season or at early bud burst (up to mid-March), but suitable thiocyanate washes may be useful in special circumstances as, for instance, where spraying is necessarily done very late or where market garden crops are interplanted.

The use of a D.N.C. wash is shown to be the cheapest method of controlling aphides, Apple Sucker, Winter Moth, Red Spider and Capsid Bugs by winter spraying.

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SPRAY DAMAGE AND APPLE CAPSID CONTROL BY WINTER PETROLEUM

By W. STEER and M. H. MOORE

Introduction.—It is widely held that petroleum spraying in the latter part of March or early in April is less apt to cause bud damage than spraying at earlier dates. Later spraying has also long been considered the more effective against Apple Capsid (*Plesiocoris rugicollis*). Experimental data bearing on either of these beliefs are scanty, and it was largely, therefore, to secure evidence that would serve as a basis for physiological investigations on bud damage that the spray trials described here were carried out.

Spray Damage.—Severe winter-petroleum damage occurred at East Malling on plums, particularly Victoria, in 1939. Although a cold spell after spraying may have had some effect, it seemed at the time that much of the damage might be due simply to over-spraying, for the trees had suffered no ill effect from similar spraying in previous years at much the same state of bud development.

In addition, therefore, to investigating spray damage in relation to the date of spraying—in an effort to link susceptibility with some recognizable condition of bud development—it seemed desirable to determine the influence of an unduly heavy deposit of oil. This could be attempted—(1) by controlling the amount of spray fluid applied. It is extremely difficult to spray some trees heavily and others lightly but adequately in any standard manner, even if differences in deposit could thereby be secured. (2) By varying the concentration of oil or the stability of the emulsion. There is no reason to suppose that either of these is of more than subsidiary importance, and to determine any influence they may have would require a range of these variants much wider than obtains in commercial practice. (3) By building up an oil deposit through alternate wetting and drying, such as often happens when spray drifts in windy weather. This was adopted as the most satisfactory means of ensuring a heavy deposit, the cumulative effect of drift being simulated by spraying twice, with an interval for drying.

Spray Damage Trial on Plums (1940).—On each of four dates, viz. 21st February, 29th February, 20th March and 2nd April, standard Victoria plum trees were sprayed with 5% of a Grade E petroleum oil. This was emulsified with oleic acid and caustic soda at 1 qt. and 6 oz. respectively per 100 gallons of emulsion. Some trees were sprayed once, others twice, the first application being allowed to dry before the second was made.

The three rows used were of trees on each of two rootstocks, Common Plum and Myrobolan B, in unequal numbers. For those on Common Plum, the spray treatments were randomized within each of three blocks, using single-tree plots. For those on Myrobolan, only two such blocks were possible.

The spraying was done with a 2 h.p. mobile machine which, particularly as a triple nozzle was used, enabled all parts of a tree to be rapidly and adequately covered. A large screen was used to control the drift. The first application was delayed by prolonged frost and snow, but nevertheless was made whilst the buds were apparently still dormant. By 29th February, the fruit buds were showing signs of movement, with pale green areas visible between some of the bud scales. There was little further movement by 20th March, for the weather had for the most part remained cold. The buds were by now well plumped and conspicuously yellow between the scales, but had not broken. By 2nd April the blossom buds were well open, disclosing the packed green flowers within. The wood buds, too, had elongated and showed yellowish-green between the scales. The weather following each spraying remained cold for a week at least, and any influence it may have had on spray damage is unlikely to have been differential.

When the trees were inspected on 19th April, it was clear that two sprayings had invariably caused more damage than one, or had caused damage when one had not, i.e. on 21st February and 20th March. Of the first three dates the latest (20th March) had proved the safest for double spraying ; only slight damage followed single spraying on 29th February. On damaged trees many of the blossom buds were dead ; they had not moved since they were sprayed, and now readily dropped. Others were producing dwarfed blossoms, and blossoms with very short stalks. On some trees leaf buds, especially those towards the middles of long shoots, were either retarded or killed. Conspicuous, too, was the blackish bark that is so often a symptom of petroleum-oil damage. The damage from spraying on the fourth date (2nd April) was of a different type, the chief symptoms being browning of the petals and scorching of the leaf tips. The damage appeared to be a little worse with Common Plum than with Myrobolan as rootstock.

Three pickings of fruit were made, on 20th and 26th August and 6th September. On each occasion the weights of the whole picking and of a sample of a hundred fruits were recorded for each

tree. From these were calculated the total number of fruits produced and the mean weight per hundred, both of which are summarized, together with the total yield in pounds, in Table I.

On Common Plum, the yield, expressed as number of fruits per tree, confirmed the results of the inspection made on 19th April. The figures showed that two applications of spray were more harmful than one, and that of the four dates, the third (20th March) was the safest. Differences could not be detected as between the other dates. The crop weights showed less pronounced differences ; they confirmed only the effect of the rate but not the time of application, for on damaged trees the fruits, being fewer, grew larger and so reduced the apparent loss. The fruits were significantly smaller on trees sprayed on 20th March than on any others, and on once-sprayed than on twice-sprayed trees.

On Myrobolan, the spraying had less effect. The yield was significantly lower on twice-sprayed than on once-sprayed trees (mean number of fruits per tree : 1,439 and 2,507 ; sig. diff. 953), but differences due to date of spraying could not be distinguished with any confidence. There was no significant effect on the size of the fruits.

The conclusion is clear ; the heavy deposit secured by spraying twice—a deposit such as can easily accrue from spraying in windy weather—was of much greater importance than the date of spraying.

TABLE I.

THE EFFECT OF PETROLEUM OIL ON THE CROPPING AND FRUIT SIZE OF VICTORIA PLUMS (1940).

On Common Plum Stock.

Spray treatment:	21/2/40. Once.	21/2/40. Twice.	29/2/40. Once.	29/2/40. Twice.	20/3/40. Once.	20/3/40. Twice.	2/4/40. Once.	2/4/40. Twice.	S.E. Diff.	Sig. Diff. (P=·05).
No. per tree ..	1,287*	565	2,020	549	2,836	1,951	1,937	860	488·6	1,048
lb. per tree ..	91·7	48·1	121·1	57·1	116·3	112·2	108·6	70·4	22·5	48·4
lb. per 100 ..	7·40	8·44	6·37	9·65	4·24	6·24	5·50	8·19	0·74	1·60

Dates :	21/2/40.	29/2/40.	20/3/40.	2/4/40.	S.E. Diff.	Sig. Diff.
No. per tree ..	926	1,284	2,394	1,399	345·5	741
lb. per tree ..	69·9	86·1	114·3	89·5	15·9	34·2
lb. per 100 ..	7·92	8·01	5·24	6·84	0·53	1·13

Rates :	Once.	Twice.	S.E. Diff.	Sig. Diff.
No. per tree ..	2,020	981	244·3	524
lb. per tree ..	109·4	70·5	11·3	24·2
lb. per 100 ..	5·88	8·13	0·37	0·80

* This low figure is the mean of 589, 1,922 and 1,350, and thus includes one poor tree with very low crop.

Spray Damage Trial on Apples (1940).—On each of five dates, viz. 11th February, 25th February, 13th March, 27th March, and 8th April, six-year-old bush apple trees—Cox's Orange Pippin on No. IX rootstock—were sprayed with the same emulsion as was used in the plum trial, but at 6% oil. On each occasion some trees were sprayed once, others twice, and for convenience these two series are referred to as " A " and " B " respectively. The spray was supplied from a 2 h.p. mobile machine through a double nozzle, and a screen was held in position when necessary to catch spray drift. The ten spray treatments and an unsprayed control were randomized within each of eight blocks, in single-tree plots.

The weather on most occasions was dull and cold. Drying was slow, and so the second application in most of series B had to be made before the trees were quite dry. The deposit of oil was, nevertheless, clearly increased. On the fourth occasion, in sunny weather, the trees were quite dry when the second application was made.

At the five dates, the condition of the buds was :

(1) 11th February—dormant.

(2) 25th February—apparently still dormant.

(3) 13th March—scales of most forward fruit-buds separating at tips, showing a wedge of light colour. No sign of inner components of the buds, which, though plump and round, were still pointed and compact at the tip.

(4) 27th March—most forward fruit-buds at stage commonly known as bud-burst, still fairly compact with bunch of curled leaf-tips protruding. Many buds not yet at this stage.

(5) 8th April—trees now clearly studded with green of fruit-buds, in which the leaves, though still folded, were becoming separated.

Observations made on 17th April showed that no bud damage had occurred beyond some retarding of the fruit buds. This was particularly evident on 2B, less so on 2A, very slight on 3B, and on some trees of 4B and 5B, and absent from 1A, 1B, 3A, 4A, 5A. The trees sprayed at stage 5, and especially 5B, looked very oily and their leaf tips were conspicuously bronzed.

On the 25th, and again on 28th April, estimates were made of the degree of retarding of fruit- and wood-buds. The two estimates, which were made independently by different observers and were based on visual impression, agreed very well. The results showed that the trees sprayed twice at the second stage (2B) were most retarded, while 1A, 2A, and 3A were no different from unsprayed controls. The remainder were intermediate, though 4A differed little from the controls. Thus, the buds on trees sprayed twice at any of the first four stages, and especially the second, were more retarded than those sprayed only once. Trees sprayed at stage 5, after bud-burst, differed from the rest in that the damage was scorching of foliage and not retarding of buds ; many of the blossom buds, especially those on trees sprayed twice, did not move after spraying but ultimately became dry and dropped off, leaving bare wood. The damage may have been accentuated by late frosts, which ruined most of the crop, and by lime-sulphur applied at the green-bud stage.

Spraying failed, in this trial, to produce severe damage such as occurred on the plums in 1940. Nevertheless, the tendency for two sprayings to cause bud damage where one did not was confirmed, likewise the indication that the buds are more susceptible to spray damage at some period, or periods, than others. Apple foliage, too, was scorched by being sprayed at late bud-burst.

In addition to this main trial on apples, 3% of petroleum oil, emulsified in the same way, was tested at stage 3. There was no damage apart from very slight retarding on trees sprayed twice.

Other Evidence.—In the light of these results it is instructive to re-examine such data as are available relating to winter petroleum damage of which we have personal knowledge, or such as can be found in the literature.

At East Malling a plot of young Cox's, Worcester, Newton and Allington, all on No. IX rootstock, was sprayed on 21st March, 1940, with 6% petroleum oil.* Some of the trees, including all four varieties, were severely damaged ; most of the fruit buds died and dropped off, the bark was black and oily, and surrounding weeds were yellowed. This damage occurred only in one patch, and subsequent enquiry showed that at this spot the machine was taken away for refilling. When spraying was resumed there was enough wind to cause drift on to the nearest trees, already sprayed and now dry.

A similar instance occurred in 1937, when severe damage to scattered groups of trees followed the application on 1st April of 5% petroleum oil,* to a plot of Cox's and Worcester. The hand-operated machine used, which held only 20 gallons, had to be pulled to the headland from time to time for refilling. The trees were drying during these intervals, and so the damaged ones were probably those that received drift when spraying was resumed. As a large tank of spray-fluid sufficient for the whole plot had been prepared beforehand, there is no possibility that the damage was due to an occasional faulty mixture.

Some of the writings of Austin, Jary and Martin (1932, 1933, 1934) contain observations on spray damage that can to some extent be related to the weather prevailing at the time of spraying, rather than to the date. Thus, in 1931, Bismarcks and Edwards, sprayed in calm weather on 17th February with 6% petroleum, or with a mixture of 6% petroleum and 4% tar oils, showed no sign of injury. Worcesters, sprayed on 3rd March, under conditions stated to be " favourable ", were not injured by 8% petroleum. Bramley's, too, were unaffected by 8% petroleum applied on 31st January, but no reference is made to the weather in this instance. In 1932, Worcesters suffered slight, and Lane's severe, bud injury through having been sprayed on 3rd February with a mixture of 6% petroleum and 4% tar oil, but again no indication is given of the weather during spraying, or of the occurrence of wind drift. In 1933 a similar mixture (as well as several other washes) was applied to Worcesters on 8th February, when the wind caused noticeable drift. Severe blossom bud injury resulted in two of the three plots sprayed with the mixture. The direction of the drift is not stated, but it is suggestive that the comparatively undamaged plot lay in a corner of the plantation. Concentrations of as much as 10% petroleum and tar oil, alone and in mixtures, were applied to Lane's on 8th

* Emulsified with oleic acid and caustic soda.

February in an attempt to cause spray damage. Here, however, drift was prevented by careful screening and there was no damage.

Steer (1933) sprayed Baths in 1932 and Derbys in 1933, both in the middle of February, and did some damage, but only with tar-petroleum mixtures and not with petroleum oil alone. There was some evidence that both wind and the instability of some of the tar-petroleum emulsions contributed to the damage.

Petherbridge and Hey (1931) found that no damage resulted from spraying Bramley's on 18th February, 1930, with 7½% of a petroleum oil emulsion, whereas a mixture of this with a similar amount of a Long Ashton type tar-oil emulsion killed some of the fruit buds. In an experiment on Derbys they used 10% petroleum emulsion (probably 8% of oil) and various tar-petroleum mixtures to compare early (27th-28th January) with later (3rd March) spraying. Fruit buds were killed by one of the mixtures applied on 3rd March. The experimenters give no indication of weather conditions.

Staniland and Walton (1932) observed bud injury, which they did not consider serious, in the course of trials of tar-petroleum washes carried out in 1931. Most of it followed spraying on 3rd February and 24th-27th February, in weather that appears to have been calm. They state that the "injuries occurred in small groups of trees and as far as could be ascertained, were coincident with the application of wash from the ends of separate mixings". Slight, but general injury followed spraying on 14th-15th January in sunny weather with some wind. In other trials, however, spraying on 2nd, 5th or 13th February gave little or no damage even though there was a light breeze at times.

There is thus little to associate petroleum oil damage with period of spraying in the published findings of the various workers, who sprayed on dates ranging from mid-January to early March. There is, however, good reason to suppose that much of it was due to spray drift. Where tar-petroleum mixtures were used other factors are introduced, such as a high total oil content, or the use of tar oil on non-dormant trees. An instance of damage that followed the use of a tar-petroleum mixture and which could not, it seemed, be ascribed solely to repeated spraying or to drift was brought to our notice in April, 1941.

A large area of big standard apple trees was sprayed on 19-20th April with 10% of a proprietary mixture. The weather at the time was warm and sunny, with some, but probably not excessive wind. The spraying was done with an efficient power machine which, though mobile, never has to stop for refilling. Almost all the buds of Newton Wonder on a four-acre block were severely damaged. Those that were not killed altogether were greatly retarded and produced poor blossoms with little or no leaf to them. The bark remained black and oily for many weeks. Neighbouring, and even interplanted, Bramley's were but slightly affected. On these, dead blossom buds could be found and were widely distributed, but, for the most part, the damage was insignificant. Nearby, unsprayed Bramley's had almost as many buds killed by *Fusarium sp.* The marked susceptibility of Newtons was observed in 1931 by Edwards (1932), who found that severe injury followed the use of tar oils and tar-petroleum mixtures even when the spraying was carried out as early as 18th-25th February, when no bud movement was discernible. He found no damage after a petroleum emulsion, but the only tar-petroleum mixture that failed to do damage was one that contained a relatively small amount of tar oil.

Capsid Control.—Staniland and Walton (1929, 1932) considered that the date of spraying made no difference to the effectiveness of the Long Ashton washes, but found that tar-petroleum mixtures were somewhat more effective applied on 24th-27th February, 1931, than on 3rd-4th February.

Petherbridge and Hey (1931) compared the relative effectiveness of sprays applied on 27th January and 3rd March, 1930, to Lord Derby apples in the Wisbech district. They found that the results differed widely on duplicate plots, and thus thought it unwise to draw definite conclusions. It appeared, nevertheless, that the later date was the more desirable for either of two petroleum washes and for a tar-petroleum mixture, though not for two forms of a high-boiling neutral tar-oil wash. Incidentally, these authors record the view of several Wisbech growers that late spraying gave better results than early with the Long Ashton types of tar-oil wash.

Hey (1934, 1936) considered that petroleum emulsions are best applied in the last three weeks of March and that, if they are to be used in February, much higher concentrations are needed. The evidence he offers is slight, for the degree of control obtained in his experiments was too high for satisfactory comparison to be made. At one centre in 1934 he reduced an infestation of Capsid by 86% with a 10% emulsion applied on 26th February, and by 90% with a 7½% emulsion applied on 27th March.

Field Spraying Trial in 1940.—On each of three dates, viz. 29th February, 20th March, and 2nd April, Grenadier apple trees were sprayed with petroleum oil emulsion. Three concentrations of oil were used—5%, 4% and 3%—the oil being emulsified, as before, with oleic acid and caustic soda. The Grenadiers occurred as alternate trees in alternate rows of a block of Bramley's Seedling, and had already been sprayed in December with tar oil; they had been very heavily attacked by

Apple Capsid (*Plesiocoris rugicollis*) the previous season. Thirty-six trees were used, the spray treatments (three dates and three concentrations) being randomized within each of four square blocks, each of nine trees. None of the Grenadiers received spray drift, for the intervening Bramley's, which themselves received a routine application of petroleum emulsion (6% oil) when drift on to the Grenadiers could easily be avoided, served as an effective shield.

No spray damage occurred except from the application on 2nd April, which produced slight scorch of the leaf-tips and some bronzing of the rosette leaves. As lime-sulphur might have accentuated this, it was omitted from the pre-blossom Scab sprays, " wettable " sulphur being used in its place. The damage ultimately proved to be of no consequence.

By the middle of April many dead blossom buds were to be found on all the trees. Their distribution bore no relation to any of the spray treatments, and was similar to that on nearby unsprayed trees. Most of them were later found to contain a species of *Fusarium*, probably *F. lateritium* Nees., commonly associated with Bud Rot on this variety, and shown by preliminary experiment to be a cause.

The infestation of Capsid was assessed on 22nd April from leaf markings. On each tree two random samples of 200 trusses were examined from the north and south sides respectively, and the proportion marked by Capsid was determined. The results are shown in Table II. The earliest spraying (29th February) was the least effective of the three. The last (2nd April) was the most effective, but was not significantly better than the second (20th March). Five per cent. of oil was more effective than either 4% or 3%, between which, however, there was no significant difference.

All the trees received nicotine, as an ingredient of the Scab sprays, at pink-bud and petal-fall. There was, nevertheless, enough Capsid-marked fruit to show the effects of the oil sprays. Counts of all the apples gave results that fully supported those obtained earlier from leaf-markings.

It is clear that 5% of oil was unsatisfactory when applied at the earliest date (29th February); indeed, the only concentrations that controlled Capsid adequately were 5% on 20th March and 5% or 4% on 2nd April.

TABLE II.

APPLE CAPSID, 1940.* PERCENTAGE OF CAPSID-MARKED TRUSSES ON 22ND APRIL.

Concentration :	29th February.	20th March.	2nd April.	Mean.
5% oil	19·2	5·1	2·3	8·9
4% oil	28·9	20·6	5·2	18·3)
3% oil	52·2	20·2	12·2	28·2)
Mean	33·5	15·3	6·6	

* The results were subjected to an analysis of variance, using the inverse sine transformation appropriate to such data (Bliss, 1937). Such differences between row means and column means as were found insignificant (at P = ·05) are indicated by brackets.

Discussion.—Two kinds of damage have been observed following the use of winter petroleum emulsions :

(1) So-called " bud-sealing ", in which the fruit-buds fail to open and ultimately drop out, and the bark is often noticeably blackened, and

(2) Scorching of the leaves, flower-buds, etc., of the opening fruit-buds, which results only from late spraying and can be due both to direct action of the spray on the young leaves, etc., and to its interaction with lime-sulphur and arsenate used in April for Scab. A harmful interaction on the tree between soap (with which the petroleum oil in the present experiments was emulsified) and lime-sulphur and arsenate was regarded as the cause of spray-damage in some experiments in Scab-control (Moore, 1934). This kind can easily be avoided by earlier spraying.

Judging from the evidence of our trials, the first kind is associated more with windy conditions than with the period at which the spray is applied. It is doubtful whether spraying in calm weather during a " susceptible " period is itself enough to cause serious damage, which, however, can readily be caused by an excessive deposit of oil. March is notoriously a windy month, often with few opportunities of spraying without risk of excessive spray drift. Although the latter half of March, when buds are moving rapidly, appears to be slightly safer than an earlier period, delays may occur so that spraying cannot be done until the second kind of damage becomes inevitable. An earlier start to spraying—say mid-February—must therefore be given serious consideration for the sake of the longer period available for choosing calm days. Admittedly, later spraying is more effective

than earlier for Capsid control, for good results can be obtained by spraying during late March or early April with no more than 5% of oil (6-7% of most prepared emulsions). But 6% of oil is almost universally used even for the later applications ; moreover, there is abundant evidence (e.g. Steer, 1933) to show that thorough spraying with 6% of oil as early as mid-February will give good results. There is thus little point in late spraying for the sake of enhanced Capsid control when such spraying carries a high risk of having to be done in unfavourable weather, or when the trees are coming into leaf, or of not being done at all.

Spray drift can be important in two respects. *General* drift occurs with the prevailing wind when, under quick-drying conditions, the trees are alternately wetted and dried. *Localized* drift occurs when spraying has to be interrupted, as when the machine must be refilled, or when half-trees are done from one alley and the other halves from the next. It is immaterial whether drift falls upon dry spray-deposit or spray upon dry drift-deposit ; either can result in the build-up of an excessive coating of oil. The damage is, perhaps, more likely to result from spraying in warm, sunny weather than in the slow-drying weather that prevailed in the apple trial described above.

Circumstances other than spray drift may influence the heaviness of the oil deposit, but it is doubtful whether of themselves they are very important. They may, however, aggravate the effect of drift or possibly tip the scale when drift alone would not be of serious consequence. One such circumstance is an unduly high concentration of oil, though a relatively large increase in concentration in the tank would be necessary to produce a small increase in deposit. This point may be of some importance with unstable, quick-breaking emulsions. It is possible, moreover, that the chance combination of several factors, may, even in the absence of drift, cause damage to the buds. The recognition and evaluation of such factors awaits precise knowledge of the physiological action of petroleum oils, especially in relation to bud development, nutrition, soil conditions and weather subsequent to spraying.

Summary.—Field spraying trials with winter petroleum oil were carried out to determine the influence of period of spraying on spray damage and on the degree of control of Apple Capsid (*Plesiocoris rugicollis*).

On plums, the rate of application (i.e. once-sprayed or twice-sprayed) was more important as a factor in spray damage than the period at which the spray was applied. On apples, the results were similar, but less pronounced. Though there are many contributory factors, an unduly heavy oil deposit, which readily accrues from spraying in windy weather, can itself cause severe bud injury.

Late spraying is imprudent because of the uncertainty of the weather and of the risk of scorching the opening blossom trusses if delays occur, although, as the data show, late spraying is more effective against Capsid. Earlier spraying should prove effective provided at least 6% of oil is used, and it gives more opportunities of choosing calm weather.

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Section IV

BULLETINS FOR FRUITGROWERS

POMOLOGY

MAKING THE BEST USE OF WATER IN FOOD PRODUCTION*

By W. S. ROGERS

ONE of the most important plant foods—and one imported free and without the aid of ships—is water. For every pound of dry matter produced by a crop as wheat or potatoes, for instance, nearly *five hundred* pounds weight of water is used by the plant.

At East Malling Research Station we have been studying the intake of water by plant roots, by means of special instruments which give a continuous record of the soil moisture conditions. These instruments installed in bare soil and under various crops, have given information which, together with the findings of other research workers in various parts of the world, suggests methods of making the best use of the soil water supply.

In many areas the water supply, which depends on the amount falling as rain and stored in the soil, can be the chief factor limiting the amount of crop produced. Either too little water in the soil or too much is harmful to plants. The aim should be to keep the soil moisture within suitable limits for the longest possible period.

One important guiding principle is this: When the soil is nearly saturated, water will move about in it relatively freely, but when the soil begins to dry water movement is greatly restricted, and in really dry soil water movement by capillary action is almost negligible. Anyone who finds this difficult to believe, can check it by digging a hole in land bearing a heavy crop (such as a hayfield) when about a quarter of an inch of rain has followed a long dry period. It will be found that only the top few inches of soil are moistened, and below this the soil is quite dry. At some distance below this again we know a water table exists. If water movement by capillary action were rapid, the moisture would obviously be distributed quickly and evenly through the soil—but this actually does not happen, under dry conditions. (Rogers, 1935, 1936, 1937, 1939.)

Several useful conclusions follow. First, water more than a few inches away from the plant roots is unavailable to the plant under dry soil conditions. Therefore we must ensure that the plant roots can extend through a large volume of soil so as to tap a good water supply, and prevent rapid drying out of a restricted layer. This is where subsoiling and deep cultivation are most valuable, and, of course, the choice of naturally deep fertile soils.

Drainage also helps to extend the depth available to roots, in soils which would otherwise tend to get waterlogged in wet periods. Seasonal waterlogging of soil causes death of roots—not actually from too much water but from lack of air. A plant with its root system restricted in this way usually actually suffers from drought when dry weather sets in and the water-level falls. Wet soils also warm more slowly than well drained ones, so delaying root activity in spring.

Thus, if a grower can extend the soil depth available to roots, it is comparable to extending the height of a factory. The productive capacity should be increased at no extra rental.

Water conservation by cultivation.—The old saying that " the hoe is as good as the water-can " is only partly true. The main water-conserving effect of the hoe is by removal of weeds, which use up very large quantities of water. Grass is a great water-user. For example, drought conditions were found three weeks earlier in a grass orchard than in a clean cultivated orchard. So weed control is very important. Whether keeping a loose crumbly surface by constant hoeing conserves water, even when there are no weeds, is much less certain. We have already seen that a dry layer of soil (either loose or compact) is an effective barrier to water movement. Moreover, excessive hoeing undoubtedly causes rapid loss of organic matter from the soil, and we know that organic matter helps the soil to absorb and retain moisture, besides having important nutritional effects. Nevertheless, breaking a surface pan with the hoe undoubtedly helps young plants, and here other factors, such as aeration, come in. Whether to hoe or not, in the absence of weeds, therefore, remains a matter for decision in each special case, from the appearance of the plants and the soil. If the land is clean and plants are doing well, the cost of extra hoeing can probably be saved, without detriment.

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Intercropping.—Under present conditions, when every square yard of ground is required to produce a maximum crop, the growing of intercrops between fruit trees, etc., is receiving some attention The suitability of various intercrops depends on many factors, but the soil moisture question is a very important one. If the intercrop is to be on the ground through the months when rainfall does not make up for the water used by the trees, only really deep soils, which hold over a good store of water from the wetter months, will be satisfactory. The minimum depth depends on local conditions, but I should consider 24 inches of good soil a minimum. During the months when rainfall exceeds water usage, roughly from the end of September to April, intercrops could safely be grown on shallower soils (so far as moisture is concerned) but the range of possible plants is more limited.

Irrigation.—The use of artificial irrigation in dry periods is well worth consideration, where a supply of water is available at a reasonable cost. It is already considerably used by vegetable growers, and at East Malling we have increased strawberry crops in each of three years by applying water at fruiting time. In one case the weight of first grade fruit was increased by 70 per cent. Even if rain follows the irrigation the effect is not wasted, for the rain penetrates better and farther on the soil already moistened by irrigation. We have found that the overhead method of irrigation (by hose, sprinkler or oscillating pipe line) is more efficient than the furrow method. The latter is cheaper to begin with, but it does not give so good a distribution of water.

For efficient irrigation, the ground should be saturated to the depth at which most of the roots are, and not beyond. A useful concept is that wetting the soil is like filling a cup of tea, but the other way round—in filling a cup of tea the bottom half must be filled before the top half ; but in re-moistening the soil block the top inch must be almost saturated before the second inch gets any, the second before the third, and so on. Therefore very light applications of water are wasteful, for they merely wet the surface without reaching the roots, and are quickly lost by evaporation. For medium sized plants (such as, for instance, strawberries) a suitable application is the equivalent of half to one inch of rain. One inch of rain is equivalent to $4\frac{2}{3}$ gallons per square yard, and this will usually penetrate to a depth of about one foot (depending on the nature and the wetness of the soil). If a water-can is used, some dry soils even when well cultivated, will not absorb as much as two gallons per square yard as quickly as it can be poured on, so several applications at short intervals may be necessary ; but a good soaking on one day is better and more economical than many light sprinklings at daily intervals. A final point is that a fortnight's drought when the sub-soil is dry, as it is likely to be in July (in a normal season), is much more serious than in May, when it is still moist from the winter rains.

Summary.—Water is one of the most important factors in plant growth. Water flow in dry soil is very slow, so a good root range, especially in depth, is essential to tap a large moisture reservoir. This can be aided by drainage and subsoiling. Cultivation is most important to control weed competition in dry periods. Artificial irrigation and intercropping are discussed.

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PRACTICAL NOTES ON COVER CROPPING OF ORCHARDS

By W. S. ROGERS

A preliminary leaflet (Hatton, Rogers and Roach, 1940) on maintaining orchard soils by the use of cover crops aroused wide interest ; and letters which we have received from various parts of the country confirm our own observations that poor foliage, chlorosis and other " deficiency symptoms ", and increased susceptibility to spray damage are reaching serious proportions. Most correspondents confirm our suggestion that this may be associated with depletion of organic matter in the soil, and not a few report that good results have followed cover cropping or grassing-down under suitable conditions. There is a wide variation of opinion and experience, however, ranging from growers who advocate the use of only organic manures (including cover crops) and the complete avoidance of artificials, on the one hand, to those who consider that only artificial manures are needed, on the other. This all emphasizes the need for obtaining exact information under controlled conditions.

There is already good experimental evidence that a sufficient supply of organic matter in the soil is of very great importance, both in maintaining soil texture and in plant nutrition, and that continued clean cultivation results in rapid losses of organic matter (Albrecht, 1938 ; Pieters, 1927). What remain to be shown are the best ways of conserving and renewing this organic matter under our orchard conditions. The wide interest shown in this problem suggests that a few preliminary notes on the experiments now in progress here would be of interest to growers. As these experiments are still in their early stages, we can only attempt to give the early indications observed under our own conditions.

These experiments are designed to test the suitability, efficiency and value of various cover crops which can be grown among the trees in a plantation, and either incorporated in the soil by cultivation or cut and left to rot on the surface. This method of supplying organic matter has the advantage that the material is produced where it is used, so minimizing handling costs. The main problem is to obtain a crop that will fit in with the normal orchard routine and that will grow at times when it will not compete seriously with the trees above it. Where this can be done successfully, it can probably replace to a greater or less extent the use of bulky organic manures, or the relatively costly and laborious making of pit- and heap-composts. It is also valuable for preventing soil erosion.

Systems of Cover Cropping. Our experiments include three systems of cover crops all grown under orchard conditions as follows :

1. *Annual Crops.*—Single or mixed crops, including tares, trifolium, lupins, peas, mustard, rape, oats, and rye, sown, grown and disced under in the course of a single season.

2. *Short-term Ley Crops.*—Single or mixed crops, including red clover, rye grass, lucerne, sweet clover, and sainfoin, grown as two- or three-year leys.

Both (1) and (2) can be grown either as strips between tree rows or to cover the whole ground.

3. *Permanent or Semi-permanent Swards.*—These include various species of grass and clover to be cut with a mower at intervals through the growing season and allowed to lie and rot (comparable with the American system of Sod-mulching).

Factors in choice of Cover Crop.—In choosing the system of cover cropping and the crops to sow, it is necessary first to consider the type of orchard conditions under which it is to be grown.

If spraying is carried out, the cover crop must either be timed to miss the spraying, or must be resistant to injury from spray drift.

If the trees are close planted or throw deep shadows, crops must be chosen which will grow well under these conditions. Routine operations such as spraying, pruning, and picking may necessitate a certain amount of trampling round the trees or bushes, and cover crops must not be chosen which would be unduly checked by this. The cost of seed must be considered and the general cost of production in relation to the equipment available on the farm.

Finally, consideration must be given to the humus-value of the cover crop, bearing in mind the total bulk to be put underground and also the composition of the organic material. The leguminous crops are particularly valuable because of their capacity for fixing nitrogen from the air and transferring it to the soil through their root nodules.

Time of Sowing.—We find that in the autumn, September to October, and again in the spring, March to April, the soil is usually both moist enough and warm enough to ensure good germination and growth of cover crop seedlings. And at these times there is no risk that the seedling roots will have to compete for moisture with the fruit-tree roots. In summer, June to July, the soil is warm enough but may be too dry to allow good germination and growth of seedlings. Another point to be considered in summer sowing is that the seedlings are likely to be competing for moisture and plant food with the tree roots when the latter are presumably drawing heavily on the reserves in the soil. Against this may be put the fact that many fruitgrowers deliberately stop cultivations and allow annual weeds to grow at this very time of the year, with the avowed object of checking growth in their trees. This is definitely a " cover cropping " practice which needs to be compared experimentally with other cover crops, but its effect is likely to be rather more variable and uncertain than that of a cultivated crop.

Preliminary Notes on Certain Crops.—A few cultural notes on some of the more usual cover crops and mixtures are given below. Many other plants are under test but have not reached the stage of a report, and the suitability of most of the crops for different soil and climatic conditions is still a matter for testing.

I. Annual Cover Crops.—*Oats and Tares* (*vetches*).—A mixture that has proved very successful here has been Winter Oats and Tares. Until recently we grew tares as a single crop (sown at 190 to 250 lb. per acre), but the practice of including oats has cheapened the mixture, which has now become 84 lb. oats and 63 lb. to 90 lb. tares per acre, and appears also to have increased the bulk of organic matter. We sow broadcast in autumn, after the fruit is picked, and disc in the crop in June or July,

before flowering. The same quantities of spring oats and tares can be sown in early spring, but they have not so far produced nearly such a large yield. Both oats and tares stood up fairly well to tar oil wash, but tares were severely checked by nitro-cresol. The chief disadvantage of this crop is the relatively high cost of seed. The tares sown in 1940 cost about 80s. per cwt., and the oats 15s. per cwt., making a cost per acre of 75s. to 100s. for seed.

Trifolium or Crimson Clover.—About 24 lb. per acre is sown in early autumn. Though checked by winter washes it has made a good recovery here, and produced a fine bulky crop by June. It should be sown in September, and is rather slow in germinating. Cost of seed was about 1s. per lb.

Mustard.—Non-leguminous and not winter hardy. A quick grower, suitable for spring, summer or early autumn use. About 28 lb. seed per acre is broadcast. Cost of seed was 9d. to 1s. lb. This crop dodges the caustic sprays, but must not be left too long before discing in, as it flowers and gets woody very quickly.

Rape.—Winter hardy, but non-leguminous. This has not done very well with us in recent years, and has produced a disapntipoingly small bulk before running to seed. It is severely checked by tar oil and by paraffin emulsions. Amount of seed, 5 lb. if drilled, 15 lb. if broadcast. The cost of seed was low, 8d. to 10d. per lb.

Weeds.—The cheapest of all cover crops, having no seed costs, but very variable in results. Chickweed makes a quick cover, and nettles and "fat hen" (*Chenopodium album*) both give fair bulk, but generally weeds do not give nearly the bulk of a good cultivated crop. They are often used as a late summer cover crop, but no comparative experimental figures of their effect are yet available.

II. Short Term Leys.—*Red Clover, Clover and Ryegrass, Ryegrass alone.*—For clover alone, we have used 12 lb. Broad Red Clover, plus 12 lb. late Red Clover, per acre. For clover and ryegrass, Broad Red Clover 6 lb., late Red Clover 6 lb., Italian Ryegrass 7½ lb., and Perennial Ryegrass 7½ lb. For ryegrass alone, 15 lb. Italian Ryegrass and 15 lb. Perennial Ryegrass. These are intended to form swards lasting 2 or 3 years.

Ryegrass alone competes most severely with the trees, and seems to have no advantage over a clover and ryegrass mixture. Clover alone seems to have good possibilities where the competition of a ryegrass mixture would be too severe. Cost of seed was, clover 2s. to 4s. lb., ryegrass about 1s. lb.

These leys can be sown either in autumn or spring. If sown in autumn, the seedlings should be allowed to become well established before any tar oil drift is allowed to fall on them.

Lucerne.—This forms a thick cover under our conditions, and produces a great bulk of leaf. Its effect in competing for water has been found rather drastic in other countries. Amount of seed about 20 lb. per acre. Cost was about 2s. lb.

Clover and lucerne are checked by tar oil, petroleum and nitro-cresol, but have recovered satisfactorily. Ryegrass is not greatly affected.

It must be remembered that these crops are on the ground during the whole summer, so their effect in moisture usage is much more severe than that of crops disced in by June. Therefore they are probably only suitable for deep soils well supplied with moisture.

III. Long Term Leys or Semi-permanent Grass. Perennial ryegrass forms the basis of the mixtures. The Aberystwyth selection S23 produces a much more dwarf leafy type than commercial ryegrass, but cost more than three times as much for seed in 1940. One large-scale experiment here is comparing much and little clover in the mixture, frequent and infrequent cutting, and high and low nitrogen manuring. Preliminary observations suggest that semi-permanent grass is only suitable for fairly large well-established trees, on a good deep soil. All the mixtures of ryegrass and clover have given excellent swards, but it is too early to forecast the results.

The two main mixtures are :

(*a*) Perennial Ryegrass (Commercial) 8 lb., Perennial Ryegrass (Dwarf leafy type, Aberystwyth S23) 6 lb., Cocksfoot (Dwarf leafy type, Aberystwyth S143) 10 lb., Rough Stalked Meadow Grass 2 lb., Wild White Clover 2 lb. per acre.

(*b*) Perennial Ryegrass (Commercial) 20 lb., Timothy 1 lb., Rough Stalked Meadow Grass 4 lb., Late Red Clover 3 lb., Broad Red Clover 2 lb., Wild White Clover 1 lb. per acre.

As these crops lock up a fair amount of nutrients in the first place, it is probably important to give a fair amount of fertilizer, especially nitrogen. We are testing applications up to 5 cwt. per acre per annum of nitro-chalk or sulphate of ammonia, given in two doses. Excessive dressings of nitrogen make the grass smother the clover.

Some fine grass mixtures are also under test. These require much less cutting, but the bulk produced is very much less, and the cost of fine grass seed is relatively high.

The policy will probably be to plough or disc in these swards after 4 to 6 years, and re-seed after a year or so.

Other Crops.—Among other promising crops are Lupins, Sweet Clover and Sainfoin, but these must await further trial before a report is made. Rye probably deserves further trial in mixtures, especially on sandy soil, but oats seem more vigorous here.

General Cultivation.—There should be little need to emphasize that, both for annual and perennial cover crops, the ground should be as clean as possible before sowing. Cover crops, when they are well established, will smother weeds, but weeds germinate more quickly than some cover crops. The disc-harrow is a most useful tool, both for preparing the ground for sowing, and for the discing-in of the crop. Even tall and bulky crops are well cut up by the disc. The final mixing of the crop with the soil may require from two to four discings.

For grass management we are testing both the ordinary reciprocating hay mower and the cylinder- or gang-mower type. Keeping the grass short with the latter greatly reduces the bulk of material grown, but effectively disposes of any problem of getting the cut grass to rot away quickly. Modern hay mowers also cut the grass very short, and quite short grass can be maintained with them, if required. All large stones should be picked off before mowing begins. Rolling them in has little lasting effect.

Inoculation of Seed.—Where leguminous crops have not been grown before, it is desirable to inoculate the seed with the correct bacteria just before sowing, to ensure good germination and root nodule formation. Lucerne, Clovers, Vetches and Lupins all require different bacteria, and the extra shilling or two for a tube of the correct culture medium, which the seed merchant can obtain and supply at the same time as the seed, is a good insurance against failure of the crop. Alternatively 200 to 400 lb. per acre of soil from a field where the crop has already grown well can be sown with the seed.

Sowing.—All the seeds mentioned can either be drilled or broadcast. Drilling gives greater economy in seed, and a possibility of better weed control by hoeing. We have broadcast all our seeds, but made rough furrows for the larger ones with the disc-harrow. Choosing a good time for sowing is very important ; and a few weeks delay in sowing in the autumn may make a large difference to yield. It is especially important to get the seedlings well established before the adverse conditions of winter and tar oil washes come upon them. The necessity for bird minding, as with other seeds, must not be forgotten.

Manuring.—While not much is known of the best manurial practice for cover crops, it seems clear that the crop should be well fed when growing, and also should be given a little nitrogen (say 1 cwt. nitro-chalk or sulphate of ammonia per acre) before discing in, to assist rotting. A fair dressing of basic slag or superphosphate at sowing and a suitable amount of nitrogen in spring and summer seem to be good practice. The correct amount of nitrogen will vary with the soil, tree, and cover crop. From 1 to 2½ cwt. sulphate of ammonia at each period seems suitable under our conditions.

Conclusions.—It is too early to attempt to assess results on tree growth and fruiting, but it appears that many cover crops can be grown successfully under our conditions, without harmfully competing with the tree.

Quickest results in supplying organic matter are given by the annual crops ; and of these oat and tare mixtures, and trifolium (crimson clover) seem among the most promising at present.

Acknowledgement.—I wish to express my thanks to Mr. N. B. Bagenal for valuable assistance in writing this bulletin.

Summary.—Cover cropping treatments for maintaining and increasing the organic matter content of the soil in orchards are described, with cultural details. It seems likely that suitable crops for various conditions can be chosen from among the annual, short term and semi-permanent crops and swards that are available.

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FEEDING THE FRUIT TREE—NEW LIGHT ON AN OLD SUBJECT

By N. B. BAGENAL

THE first year of war has brought about a revolution of agricultural methods the like of which has never been seen before in this country. On every hand farmers are on the look out for new ideas which will help to produce larger crops of better quality. Such conditions are nothing short of a golden age for the research worker. In such fertile soil he sows his new ideas confident that wartime farmers will be quick to try out anything that is really going to be of practical value to them.

One such idea that ought to be readily taken up is the use of a new system for gauging the mineral requirements of the plant, a system which can be adapted to most agricultural crops of economic importance. It is based on the discovery made in recent years that our old friends nitrogen, phosphorus, and potash, are not the only minerals to be considered when planning the manurial programme. The fruitgrower in particular has got to face the possibility that deficiencies of iron, magnesium, manganese, lime, zinc, and even boron, may cause serious trouble to the health, growth and cropping of his plants. Agricultural textbooks in the past whilst admitting that these minor elements are essential constituents of the plant, have tended to lull the farmer into a false sense of security by implying that almost all agricultural soils contain more than enough for the needs of the plant. But one of the vital discoveries of to-day is that it is not enough to have these various minerals present in the soil *they must be in an available form, and there must be a proper balance between them.* Take the case of a heavily limed soil low in organic matter and containing large quantities of iron. In such soils it is not uncommon to find plants suffering from chlorosis or yellowing of the leaf due to a deficiency of iron. The explanation of this phenomenon appears to be that although there is no shortage of iron in the soil, owing to excess of lime it is not in a form that the plant can use.

In South Africa chlorosis due to a deficiency of manganese was found in soils which although containing large quantities of that element, had been treated with lime and were low in organic matter. Recent investigations suggest that excess phosphate in the soil also interferes with the normal uptake of iron, manganese, and other elements.

How does this affect the fruitgrower in his own fruit plantations ? He may say perhaps " That plantation of mine isn't doing nearly as well as it should. I have always ' done ' it well, it can't be short of N.P.K., it isn't overlimed, and there's nothing wrong with the soil that I know of." True, but has he been depriving his soils of organic matter by years of clean cultivation ? Has he been giving up organic manures in favour of inorganic artificial fertilizers, thus still further depleting his soil of its organic content ? Has he been adding lime to a soil already alkaline or neutral ? Or lastly, has he been giving his soil large dressings of phosphatic manures ?

There is also the possibility that his soil doesn't contain, and perhaps never did contain, enough of some element which is only needed in minute quantity, some element which we don't think about, like copper or nickel or cobalt, or indeed hardly have heard of, like molybdenum, and that that is the reason why he never gets a really satisfactory crop from that soil. Fortunately, if only we can discover which of the minor elements is deficient, the amount required is so small that the cost of applying it is probably also small. If then the scientists can perfect rapid means of detecting these cases of deficiencies, it is going to mean a lot in hard cash to the farmer ; it is going to mean that land looked upon as second class or even hopeless, may be vastly improved at, it may well be, quite trifling cost.

What the new learning on these matters has to tell the farmer is that these conditions may now be obtaining on his farm, thus providing one of the conditions of faulty mineral balance, and that he may be faced with any one of a number of problems connected with *faulty mineral nutrition*—there may be plenty of iron, magnesium, zinc, or manganese in his soil but for one of the reasons mentioned above his plants may not be able to use them.

How can the Farmer tell ? How can the farmer tell when his plants are suffering from one of these minor element deficiency troubles ? Analysis by ordinary methods is quite impracticable owing to the large and increasing number of elements involved and the minute quantities in which some of them occur. It has been the job of the Biochemistry workers at East Malling Research Station to work out a technique by which to tell how much iron, manganese or other minor element is actually present in the leaf of the plant. This is done mainly by spectrochemical analysis. A small portion of the leaf is heated to a very high temperature, causing many elements to send out

light each of its own characteristic colour. This light is passed through a prism and is thus separated into its different colours as in a rainbow or " spectrum " which is then photographed, each colour appearing as a line on the photographic plate. Since the colours of the spectrum always appear in the same relative position to each other, an examination of the photograph or " spectrum " will tell what elements are present, and the density of the lines may be used to estimate the quantities of the various elements. The limitations of this ingenious idea will at once be obvious. The spectrogram may show a deficiency of iron in the leaf of the plant ; it may also show a deficiency of some other element such as zinc or magnesium—*but which element does the plant really need ?* This is where Dr. Roach's new injection technique comes in. For he can introduce liquids at will into a selected part of a plant as small as a fraction of the surface of a single leaf, or as large as an entire tree. By thus injecting minerals in solution and observing their effects on the growth of the leaf, deficiencies can be diagnosed within a few days. If the spectrogram shows the leaf to be deficient both in iron and in manganese, Dr. Roach can quickly determine by a series of injections whether the abnormal symptoms in the plant are due to a deficiency of either or both of these. Either the injection or the spectrochemical method is valuable by itself but the combination of the two is an immense improvement. The spectrochemical method can be used on leaves long after they have been removed from the plant ; it will show lack of balance in composition and suggest which elements should be injected. Thus it gives, in many cases, a quick diagnosis of the trouble which can be confirmed by injection and in many cases the injection can be used as an actual cure.

Combining the two methods.—During a visit to South Africa in 1939 Dr. Roach was able to test his method for combining spectrochemical analysis with diagnostic injection. In the course of a " mineral status " survey of fruit trees in the Western Cape Province he was able to compare his own diagnosis by injection on the one hand with recent manurial experiments in the district, and with the experiences of local fruitgrowers, and on the other hand with the results of spectrochemical analysis of specimens sent home to England. In the course of this work carried out by Major Thompson at East Malling healthy leaves of similar fruit plants, e.g. pears, apples, etc., taken from orchards in South Africa and England were analysed for comparison with unhealthy leaves from both places. It was possible to establish a standard of comparison in regard to the mineral composition of the healthy leaf—a yardstick by which to measure the unhealthy one. The results of the spectrochemical analysis were cabled back to South Africa in time for Dr. Roach to use them in conjunction with his own diagnostic injection work and any field data available on the spot.

It is not often that a research worker has the satisfaction of seeing his ideas applied successfully to the farm while they are still in the experimental stage. But such was the case in South Africa, where a severe chlorosis of peach trees, proved by Dr. Roach's leaf-stalk injection to be due to manganese deficiency, was successfully treated by curative injection on a commercial scale, the injections being made by Cape coloured labour at a cost of 2d. a tree. These peach trees had gone out of bearing and were about to be grubbed, but recovered after the treatment and gave a full crop, worth £2-£5 per tree.

Conclusion.—Two points in conclusion. First, let no fruitgrower be deceived by this article into thinking that if his trees are not cropping well, the trouble *must* be faulty feeding. There are a whole lot of other factors which may be operating singly or together to produce bad results : drainage may be impeded, frosts may be taking the blossom, cross-pollinators may be lacking, pruning may be at fault, insect pests, fungus, bacterial or virus diseases may be doing the damage.

Secondly, if all these things can be ruled out and especially if the plants are showing curious leaf symptoms, then the question of feeding must come under consideration.

In such cases Dr. Roach and his staff here would like to be sent specimens of leaf and shoot.

The best way of sampling is to cut ten complete current year's shoots (preferably extension shoots that are still growing) from trees or bushes showing the symptoms, and if possible, a similar number from trees or bushes of the same variety nearby which appear to be quite normal and show no symptoms. These should be packed in damp wood wool in a wooden box, addressed to the Biochemistry Laboratory, East Malling Research Station, and dispatched so as to arrive here on any day except Saturday. With the specimens should be sent as much information as possible about the trees from which they are taken.

Summary.—A popular account of new methods now under trial for diagnosing minor element deficiencies in fruit plants by means of the spectrograph and also by injection.

SOME PRACTICAL POINTS IN THE GROWING OF LOGANBERRIES AND BLACKBERRIES

By A. B. BEAKBANE and N. B. BAGENAL

Introduction.—The object of this article is to bring to the notice of fruitgrowers certain points of practical importance which have been brought out in the course of ten years' experimental work at East Malling on the growing of Loganberries and Blackberries.

In earlier reports accounts have been given of similar work on black currants, raspberries and red currants. With all soft fruits researches here have followed along the same lines ; namely, collection, description, and identification, followed by the raising in bulk of true or " clonal " varieties and the carrying out of comparative variety trials. The most important diseases to which the varieties are susceptible and methods of elimination or control have been studied at the same time.

The Loganberry and other Hybrid Berries.—The first step in this investigation, as in all those dealing with the classification of soft fruits, was to obtain from the most reliable commercial sources collections of plants of Loganberry, Phenomenal Berry, Laxtonberry and other hybrid berries. A preliminary examination of these collections showed that a large number of plants grown under the name of Loganberry differed from each other in one or more botanical characters, and that in other cases botanically similar plants had been sent in under more than one name. This had also been observed in former years in the case of the black and red currants and the raspberry, and as with these fruits, before any reliable trials could be carried out a detailed botanical description had to be made first of such true forms as were known to exist, and then of the numerous variants which as rogue varieties had found their way into commercial plantations. In each case the full portrait of the variety took a good deal of piecing together. Detailed botanical descriptions of Loganberry, Phenomenal Berry, Laxtonberry and some 47 variant forms were made over a period of eight years, involving more than nineteen hundred observations. These descriptions have proved invaluable as a standard of comparison. Any case of doubtful identity can now be referred first to the standard descriptions, and if the specimen does not tally in botanical characters with one of these, further reference can then be made to the " Rogues' Gallery " of variant forms to determine which of these it most nearly resembles.

In addition to this work a survey of commercial plantations in the main Loganberry growing districts of England was carried out, and showed that many varieties including both Phenomenal Berry and Laxtonberry were being grown as Loganberry. Some plantations were found to contain a large proportion of variant forms of " rogue " Loganberries, some bearing practically no fruit, and others carrying poor crops of malformed berries. Sometimes these variants have been deliberately raised from seed in the mistaken belief that they came true by that method, sometimes they may have come in as chance seedlings of the true variety from fruit which dropped and seeded in the plantation.

Of immediate practical importance to growers is the method of distinguishing the true Loganberry from the true Phenomenal Berry by a comparison of botanical characters in the field. The prickles on Loganberry cane are light red in colour, those on Phenomenal Berry are purple ; the leaf surface of the Loganberry is flat while that of the Phenomenal Berry is convex. In leaves with three leaflets on the current season's cane there is a further difference : in Phenomenal Berry the bases of the lobes of the terminal leaflet overlap, but in Loganberry they seldom meet and are usually widely separated. One further method of distinguishing the two varieties is that most of the fruits in Phenomenal Berry are borne singly, but in Loganberry they are mostly in pairs.

The Laxtonberry, sometimes found as a rogue in Loganberry plantations, can be distinguished from this and from Phenomenal Berry by the dark green glossy appearance of the leaf, by the very small flowers and by the rounded fruits.

Propagation.—When the description of the botanical characters of the Loganberry and other hybrid berries was completed the next step was to raise plants of each clone in bulk to provide material for comparative trials. Methods of vegetative propagation of these fruits have already been described in detail in this Station's reports*, and here reference need only be made to the tip-layer nursery in which clonal parent canes are planted 9-12 feet square and cut back to 9 inches. Each new cane is bent over when long enough, and layered by the ordinary " tip " method. The nursery can be

* Growers who have 6 ft. by 4 ft. frames and lights might be interested to try the new method of propagation by leaf-bud cuttings described in last year's *Annual Report* on page 218.

kept going for many years but no fruit should be allowed to form for fear of seedlings occurring among the tip plants.

Variety Trials.—Having raised sufficient plants from clonal races of the Loganberry and other hybrid berries the next step was to plant out comparative trials to test vigour and cropping. A five years' trial of Loganberry and Phenomenal Berry has revealed the following points of interest to the practical grower.

Loganberry has grown rather more vigorously and has carried heavier crops; Phenomenal Berry has given larger fruits, brighter and more attractive in appearance than Loganberry; the canning qualities of the two varieties, from tests carried out at Campden, appear to be about equal, the fruit of Loganberry in the can being rather the darker of the two.

Two comparatively recent imports from America have shown sufficient promise to be of interest to growers in this country.

Youngberry, a cross between Phenomenal Berry and Mayes Dewberry, ripens soon after Loganberry and before Himalaya Blackberry. It makes comparatively weak cane-growth compared with either of these and is chiefly remarkable for the large size of its fruit. The colour of Youngberry is dark wine, and its canning quality is excellent.

Boysenberry can be distinguished from Youngberry by the fact that its fruit and the undersurfaces of the leaf are more hairy, but in other respects the two varieties are much alike.

Cane Spot Fungus.—The cane spot fungus can do much damage to Loganberry in some years and is harder to control than on raspberry because the summer spores do not appear until the leaves are already open and susceptible to spray damage. The disease can be distributed by spores carried in water and when the young canes are tied below the fruiting canes, a common practice in training, they are liable to become infected with cane spot during the growing season. For this reason an experiment was devised to include a trial of four training methods and different spray applications to Loganberry and Phenomenal Berry and from these trials the following points of practical importance to fruitgrowers have emerged.

Training Methods.—From the point of view of cane spot attack, the training method known as Weaving produced the best results. In this method the plants were 12 feet apart, in rows 7 feet apart. The fruiting cane was woven between three wires at 3 feet, 4 feet, and 5 feet above ground level, and the young canes were trained first vertically upwards from the centre of the plant and then horizontally along a 6 foot wire above the fruiting canes to right and left, being tied in position with soft string as they grew.

Another good training method from the point of view of reducing Cane Spot infection was that known as the Fan. In this method the plants were at 6 feet apart in rows 7 feet apart. The fruiting canes were tied singly to the wires in the shape of a fan, long canes being cut back to within 6 inches of the 5 foot wire and weak shoots cut out at the base. The young canes were trained first vertically and then horizontally along the 6 foot wire as in the weaving method. In all training methods a special point was made of cutting out and burning the fruiting cane as soon as possible after the fruit was picked.

Over the five-year period of the experiment the largest crop per plant came from the weaving method and the largest crop per acre from the fan method. The difference in crop per acre is due to the fact that the fan method included twice as many plants per acre as the weaving method. The probability is that if plants were put in at 9 or 10 feet apart and trained by the weaving method they would give a higher crop per acre than under any of the other training methods.

Spraying against Cane Spot.—Owing to the fact that Cane Spot never attacked the trial plots severely during the period of the experiment it is difficult to make detailed recommendations for the control of the disease by spraying until the further trials now being carried out are completed. From the point of view of the practical fruitgrower a spray programme to ensure an adequate control of Cane Spot under a good training method might have to include Bordeaux mixture (4 : 6 : 100) in May before the blossom opens, colloidal copper in June, and Bordeaux mixture (4 : 6 : 100) after the crop has been picked. The experiments on the control of Cane Spot described above brought out an important difference between Loganberry and Phenomenal Berry, the latter being much more resistant to attacks of the Cane Spot fungus than the former. Unfortunately, however, the superiority of Phenomenal Berry in this direction is largely cancelled out by the discovery that it is susceptible to a virus disease known as Dwarf which dwarfs the plant to such an extent as to render it useless. Youngberry and Boysenberry have also been attacked by this virus which, however, has not yet been found in true Loganberry in this country.

Cultivated Blackberries.—*Varieties.*—From a study of the various cultivated blackberries grown here the following points have arisen which are of interest to the practical grower. Himalaya Berry and Black Diamond were found to be identical in all botanical characters. In trials Black Diamond made rather stronger cane than Himalaya, cropped at the rate of about 15 cwt. more per

acre, and had slightly larger fruits. Since Black Diamond had been claimed to be seedless and to make a better canned product than Himalaya Berry, fruits from both varieties were sent to the Campden Research Station. However, the trial showed no appreciable difference in canning quality or in number of seeds. Black Diamond in fact appears to be simply a more vigorous and heavier cropping strain of Himalaya Berry. The well-known Parsley Leaved or Cutleaf Berry was received from two sources in two forms, the only difference being in the degree to which the leaflets were divided. Form A in which the leaflets were more deeply divided proved in a five years' trial to bear a heavier crop of larger fruit than Form B.

A survey of some 18 commercial plantations of cultivated blackberries carried out whilst these trials were in progress confirmed earlier findings in regard to the similarity of Himalaya Berry and Black Diamond and revealed the fact that more than one form of Parsley Leaved Berry are being grown.

Propagation.—A study of the different methods for raising blackberries has shown that "tips" taken straight from the mother plant have soft white fleshy roots and fragile shoot buds. The roots are easily broken and dry out quickly and if the shoot buds are damaged in transit the young plants receive a severe check. Tips which are bedded out in the nursery for a year have much stronger roots and shoots and are thus better able to withstand exposure and damage in transit. This difference should be taken into account when ordering young plants. If these have a long journey to make from the source of supply to the plantation they should be bought as one year bedded tips. But if raised on the spot or close by, tips straight from the mother plant should be suitable.

Diseases.—The Cane Spot fungus has not proved to be a serious disease on cultivated blackberries, but both Himalaya Berry and Parsley Leaved Berry have been found to suffer from the "Dwarf" virus disease. The variety, Sherlock Junior, is frequently attacked by a fungus disease, Purple Blotch, but so far as is known this disease has not yet been found in epidemic proportions in plantations of cultivated blackberries in this country. When starting to grow any of these fruits it is all-important to ensure the planting of carefully selected plants of the variety required, free from "Dwarf" in the case of Phenomenal Berry and the blackberry varieties, and the Loganberry should be raised in special nurseries where infection of Cane Spot from the proximity of old fruiting canes is impossible.

Training Methods.—Since most blackberry cane is stouter than Loganberry cane some of the training methods used for the latter, e.g. weaving and fan, are unsuitable for the former plants. Blackberries may be trained successfully by dividing the canes into four groups and tying these to wires at 5 feet and 3 feet 6 inches from ground level. When this method is used, the young canes should be tied to a wire at 2 feet above ground level.

Summary.—The work on the identification and classification of loganberries, blackberries and hybrid berries is described. Attention is drawn to botanical characters which differentiate some of the main commercial varieties showing how they can be distinguished in the field.

Experiments to determine the part played by cultural methods such as training methods in controlling the Cane Spot disease in loganberries are briefly described.

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ENTOMOLOGY

WORK AT EAST MALLING ON THE CONTROL OF THE STRAWBERRY APHIS

By A. M. MASSEE and R. M. GREENSLADE

Past Work.—Before the vaporized nicotine method of aphis control was applied to the strawberry aphis much time was spent in endeavours to control this insect by more usual means. Spraying with nicotine was first tried and some success was obtained by the use of nicotine and soft soap, but control was never complete. Dusts were also tried in view of the lack of water supply in most strawberry fields, but proved useless. Attention was then turned to the problem of wetting the strawberry leaf, but this could not be improved either by the use of different wetting agents or by different types of nozzles and spraying methods. Atomized spraying then seemed a possibility and during two seasons it was given a thorough testing. This method was found to be possible only with the aid of a dragsheet to confine the fine mist over the plants. Results with pyrethrum extract were no better than with ordinary nicotine spraying, that is to say the kill rarely exceeded 50 per cent. and never 80 per cent. of the aphides present on the plant. Using an aqueous solution of nicotine it was possible to obtain an almost complete kill, but this was dangerous to use and could not be recommended. Atomized nicotine is in many ways more dangerous than the hot nicotine vapour against which a mask can be worn if necessary.

The Present Situation.—The use of vaporized nicotine has now practically solved the problem of the control of strawberry aphis. This method of aphis control, in which the insects are subjected to a cloud of hot nicotine vapour, was developed in the U.S.A. for the control of aphides on peas, and in 1937, following conversations with Mr. C. E. Palm of Cornell University, it was tried at East Malling against the strawberry aphis. In the laboratory the results were satisfactory and in the field experiments it was evident that the principle was sound, but further work had to be abandoned owing to the expense of the necessary machinery. In 1939, however, Pest Control Ltd. of Harston, Cambridge, had constructed a machine which they intended to use commercially, and with their collaboration a trial was carried out at East Malling. Three acres of a four-acre field were treated and a kill of 99·8 per cent. was obtained, that is, the aphis was almost exterminated. The aphis population was sampled regularly throughout 1939 and 1940 by the method described by Greenslade and Pearce (1940) and in October, 1940, 13 months after treatment, the population of the treated part was still only a third that of the untreated part of the field. Furthermore there were more aphides on the side nearest the untreated block which suggests that the re-infestation took place by means of migrating wingless aphides from the untreated block (there were no winged forms here in 1940), and that if the whole field had been treated, there would have been no aphides here a year after treatment. (Massee and Greenslade, 1939.)

Future Work.—The extremely low aphis population of 1940 (owing to the very severe weather in the winter of 1939-40) made it necessary to postpone experiments in 1940. In July 1941, however, all the Research Station commercial strawberry plots were treated by Pest Control Ltd. with equally successful results. One aphis was found alive on a sample of 400 leaves. Future observations will determine whether the few aphides left can breed up again, and if so, how rapidly. It should be noted that nicotine vapour as used at present is effective against aphides only and does not kill predacious insects, such as ladybirds. It is therefore highly probable that the few remaining aphides will be exterminated by these insects. The aphis being eliminated from the Research Station it will also be possible to study any re-infestation from a distance which may occur. The present is an ideal time for such a study as there are now no strawberries within a mile of the farm and under present regulations they cannot be planted. The elimination of the aphis, together with rigorous roguing of existing stocks of plants, would make it possible to raise virus-free strawberries here even more easily than at present. Even if the aphis returned in small numbers at migration time from sources more than a mile away, all plants could be treated immediately after migration to ensure that they are kept free of aphis. This would be particularly easy at East Malling since experience has shown that the winged aphides are only about for a week or ten days in the early summer whereas in some parts of the country they may last as long as six weeks. In the latter case nicotine fumigation would have to be left until all migration had ceased, by which time some breeding would have taken place on the newly infested plants, thus increasing the chance of spread of virus.

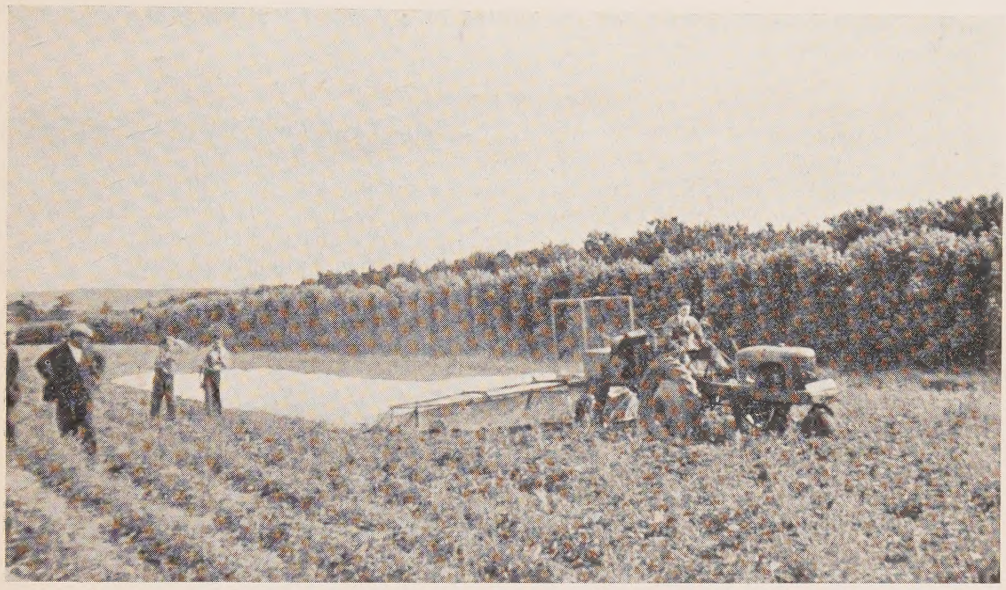

FIG. 1.
The nicotine vaporizer at work.

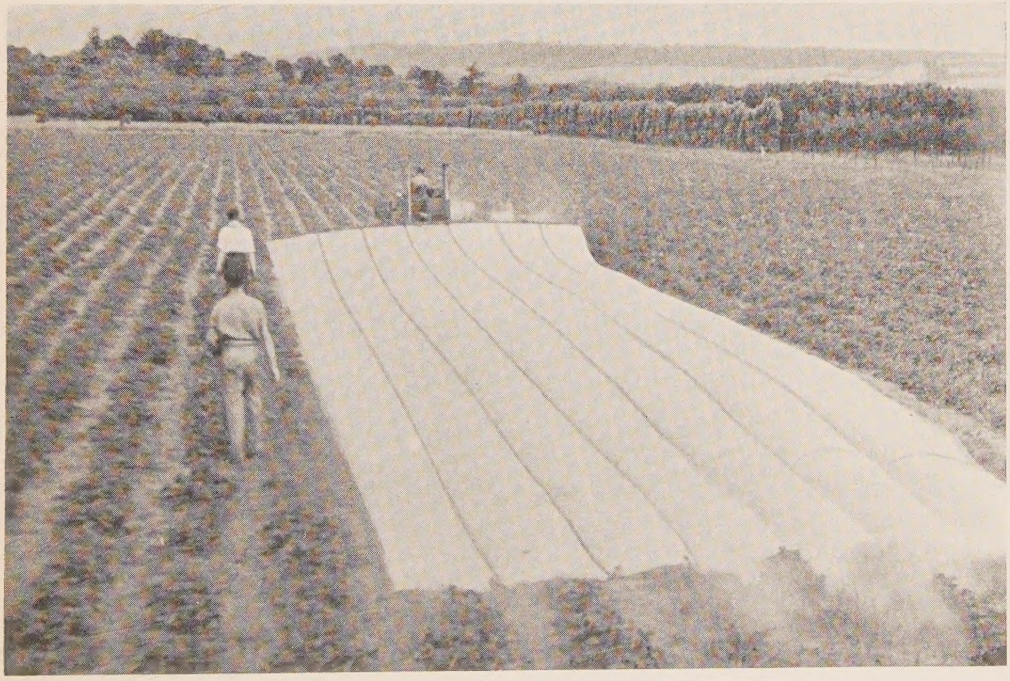

FIG. 2.
View from the rear. The clouds of vapour in the foreground shows that the concentration is maintained for the whole length of the 100 ft. sheet.

We are grateful to Dr. W. E. Ripper of Pest Control Ltd. for his interest and collaboration in these experiments.

Summary.—The successful control of the vector of strawberry virus diseases (*Capitophorus fragariae*) by the use of vaporized nicotine is discussed.

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THE CONTROL OF THE HOP RED SPIDER

By A. M. MASSEE and R. M. GREENSLADE

RECENT experiments at East Malling and in commercial hop gardens suggest the following programme for the control of the Hop Red Spider.

Formula.

Lime-sulphur	1 part.
Water	99 parts.

(No spreader required.)

Date and method of application.—The spray should be applied in May or early June, when the lower leaves of the bines have been stripped (a practice to be recommended when red spider is present), but before they reach the breast (or tying-in) wire.

The spray can be applied by means of a power sprayer or by a "hop washer" machine. A fine spray should be used, care being taken to wet the under surfaces of the leaves.

One application should prove sufficient, but in gardens where the red spider persists each year a second application should be made ten days later.

The object of the early lime-sulphur spray is to destroy the adult mites before egg-laying begins in earnest, and before the mites begin to spin their webs on the under surfaces of the leaves.

Experiments have shown that the above spray will not scorch the leaves of the bines, nor will it check the growth.

If for any reason the application of the lime-sulphur spray is not applied until July, care must be taken to make sure it does not clash with the Bordeaux mixture, which is used as a routine spray against Downy Mildew. A period of ten days should elapse between the application of the two sprays.

It must be emphasized, however, that the early application of the lime-sulphur spray is strongly recommended.

Summary.—The method of controlling Hop Red Spider by lime-sulphur spraying is outlined.

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